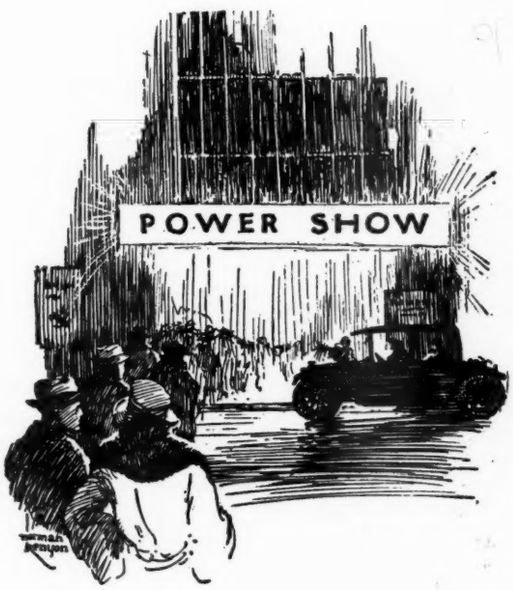
POWER

Volume 58 New York, December 4, 1923 *Number* 23



SIMULTANEOUSLY with the Annual Meeting of the American Society of Mechanical Engineers comes the Power Show.

This is the second year that it has been held, and this year it is going to be twice as big as it was last.

It offers an opportunity for the men who invent, design and build power-plant machinery and appliances, to meet the men who specify them and the men who operate them. They can tell one another their troubles and reason together for their common good.

We are publishing some spark plugs from outstanding engineers of all three types, that may explode some charges of thought and animate the discussion for which the Power Show and the inter-session seasons of the meeting afford so excellent an opportunity. The Power Show is capable of being made a powerful adjunct of the Fall Meeting of the A.S.M.E., even, as I suggested in a previous issue, affording an opportunity for the exemplification of the processes and the operation of apparatus described in the papers.

It is part of the education of every power-plant engineer to know what there is that is available for his use; its advantages and limitations. The Power Show offers him a chance to see many of the newest, and to argue about them with men who know. We hope to see it continue and gain in interest and educational value year by year.

F. R. Low

The Emmet Mercury Boiler

Some notes on its development; problems encountered and a description of the Hartford installation; the first of its kind to be placed on commercial load

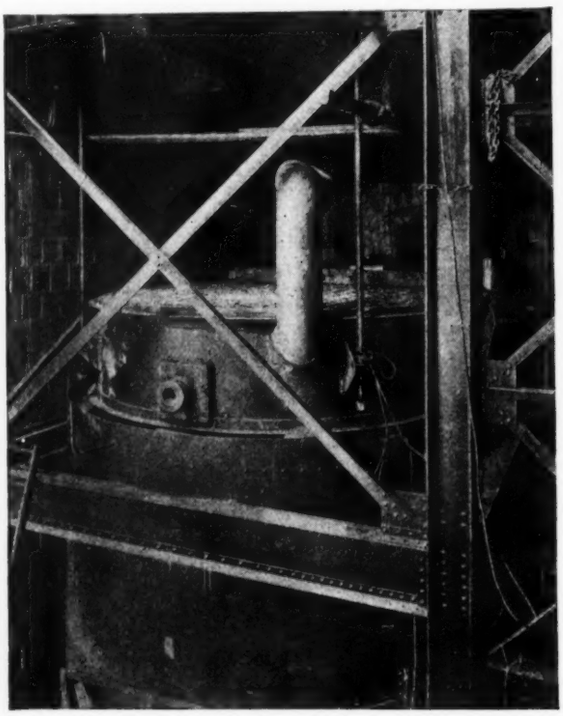


FIG. 1—VIEW OF MERCURY BOILER, VAPOR PIPE AND FURNACE CASING

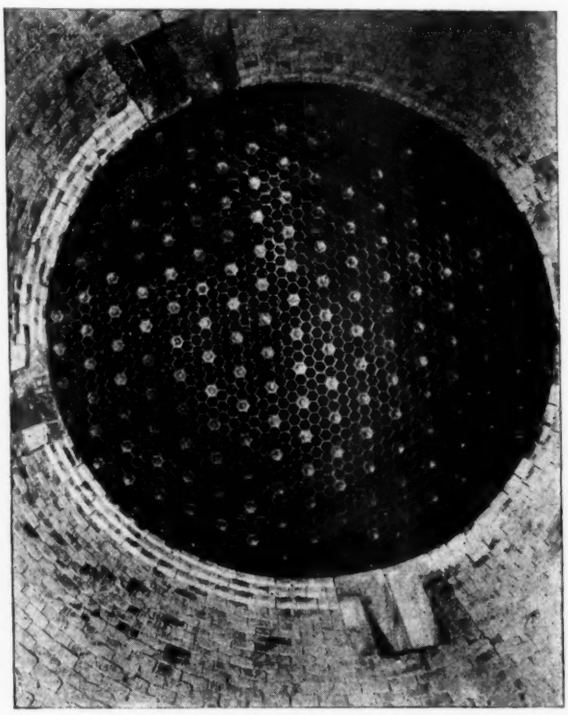


FIG. 2—BOILER VIEWED FROM UNDERSIDE; WHITE SPOTS SHOW DOWN TUBES

WIDESPREAD interest has been aroused over the recent starting up of the mercury boiler and turbine at the Dutch Point Station of the Hartford Electric Light Company. Since this installation was designed, much valuable knowledge has been developed and it should be regarded as a step in the development of the process. There have been a few troubles, mainly in connection with the gas sealing arrangements. It has been run many times and has carried as much as 1,500 kw. At first it was thought that the boiler had been overheated but indications are that this was a mistake. Experiments are proceeding with much caution, but the prospect seems to be very good that the equipment can soon be put into commercial service with conditions practically as designed.

Development of the mercury boiler has been going on steadily since 1914, when W. L. R. Emmet first actively took up the work. Mr. Emmet is a man of ideas, with the requisite resourcefulness and tenacity to carry them through to successful issue. This was evidenced by his fathering of the electric drive for naval work in spite of strenuous opposition from certain quarters at the time, and he has had the satisfaction of seeing it adopted as standard for all capital ships in the United States Navy. The electric drive, however, was a somewhat different proposition from the mercury boiler in that this principle had been well established in stationary practice and it merely had to be adapted to marine work. The mercury boiler, on the other hand, represents pioneer work in which not alone the designs and methods of construction had to be worked out through experimentation, but the thermodynamics also had to be established to a large extent. The Hartford boiler is the fifteenth design to be constructed to date, the others having been tried out with varying degrees of success in the General Electric works at Schenectady. Some of these designs have embodied the fire-tube principle like the Hartford boiler, while others have been of the mercury-tube type. With each the aim has been to construct a boiler that will not require a prohibitive amount of mercury, will not overheat and will be free from injurious expansion strains. Moreover, all joints must be welded to prevent the escape of mercury vapor to the atmosphere and the ingress of air into the system, which would produce oxidization; and finally, the circulation must be such that all liquid will immediately return to the boiler. The problem of designing the turbine has been comparatively simple.

It may be of interest to relate here that in the previous boiler set up at the Schenectady works, a steam load was carried continuously for several weeks to help out the shop demands, and the operation was entirely satisfactory. At the end of this period the boiler was shut down. Up to that time the boiler had been kept full

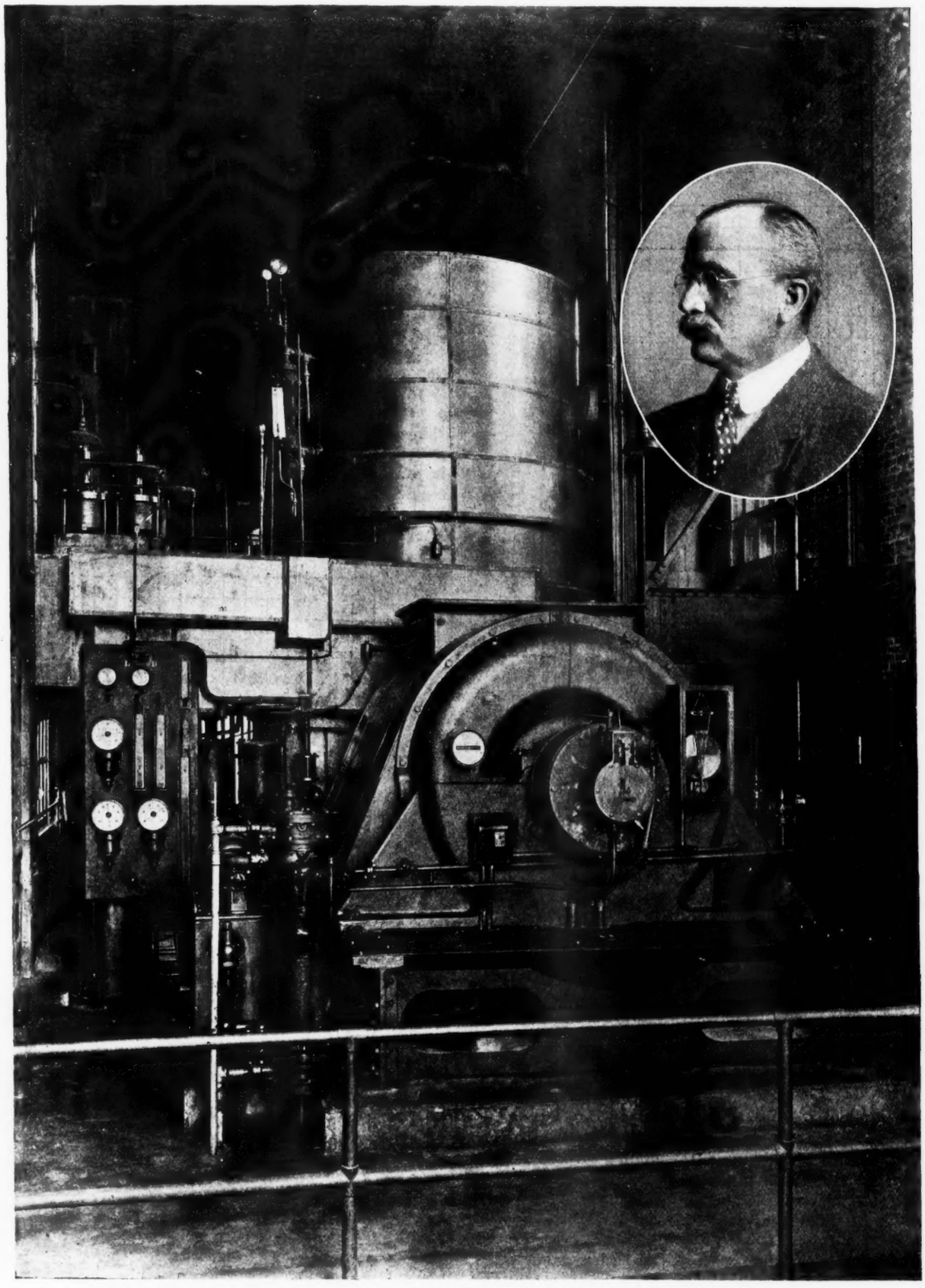


FIG. 3—MERCURY BOILER AND TURBINE INSTALLED AT HARTFORD; W. L. R. EMMET IN OVAL

of mercury and incident to the fact that it was drained and refilled at this time certain oxide and other solids which had been carried to the boiler by the circulation choked some of the small circulation spaces and caused some of the tubes to be overheated.

For the benefit of those not familiar with the principles involved, it may be pointed out briefly that the process provides for the vaporization of mercury in a boiler (at 35-lb. gage and 812 deg. F., in the present

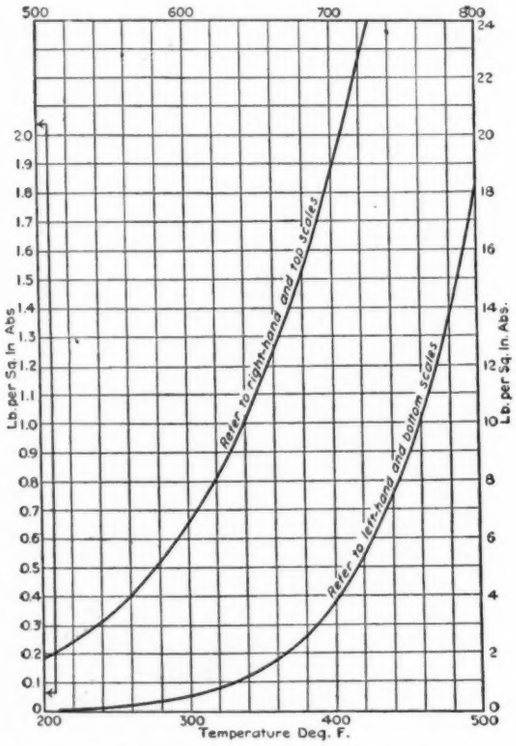


FIG. 4—VAPOR PRESSURE OF MERCURY

case), expanding the mercury vapor through a turbine and utilizing the heat of the exhaust (at 29 in. vacuum and 414 deg. F. in the Hartford boiler) to generate steam, which is put through a separate turbine or supplied to the station main as at Hartford. That is, the mercury condenser surface is the steam boiler. In this way advantage is taken of a much greater temperature range than is possible with steam alone, and the thermal efficiency approximates that of the internal-combustion engine; namely, a kilowatt-hour at about 11,000 B.t.u.

The possible rate of gain that may be accomplished by the mercury vapor process, as compared with steam plants, is entirely dependent upon the conditions and efficiency of the plant with which the comparison is made. If we compare it with a steam-turbine generating plant running at 200-lb. steam pressure and with the highest standards of efficiency in turbines and auxiliaries, the mercury-steam combination with mercury at 35-lb. gage, should, according to Mr. Emmet, give about 52 per cent more output in electricity per pound of fuel; and, if in such a plant the boiler room is re-equipped with furnaces and mercury apparatus arranged to burn 18 per cent more fuel, the station capacity with the same steam turbines, condensers, auxiliaries, etc., would be increased about 80 per cent. Comparing with stations operating under high steam pressures, the gain would, of course, be less.

Figs. 6 and 7 represent a section through the outfit, as actually installed at Hartford, with the approximate temperatures indicated. It will be noticed that the turbine and mercury condenser (steam boiler) is above the mercury boiler, so that the condensed mercury returns by gravity and thus eliminates the feed pump. The only pump in the system is a vacuum pump of the water-seal type which sucks through a canton-flannel screen. Every joint in the system is welded so as to avoid any possible leakage of air or mercury vapor.

The boiler is oil fired and the flue gases, after passing up through the mercury boiler, are led to a mercury heater or economizer, thence over the steam superheater to the feed-water heater and finally to the stack, at the base of which is an induced-draft fan (not shown). Thus the gases are brought to temperatures equivalent to those employed in steam systems. The mercury vapor passes through the boiler to the turbine, which is of the single-stage impulse type and is expanded to a pressure corresponding to 29 in. of vacuum. From the condenser the mercury liquid flows into a sump and drains back into the boiler. The mercury boiler is of the vertical type, cylindrical in form, and has a single tube sheet into which the tubes are expanded and then welded; the lower ends are free to expand. The lower two-thirds of each tube is hexagonal in

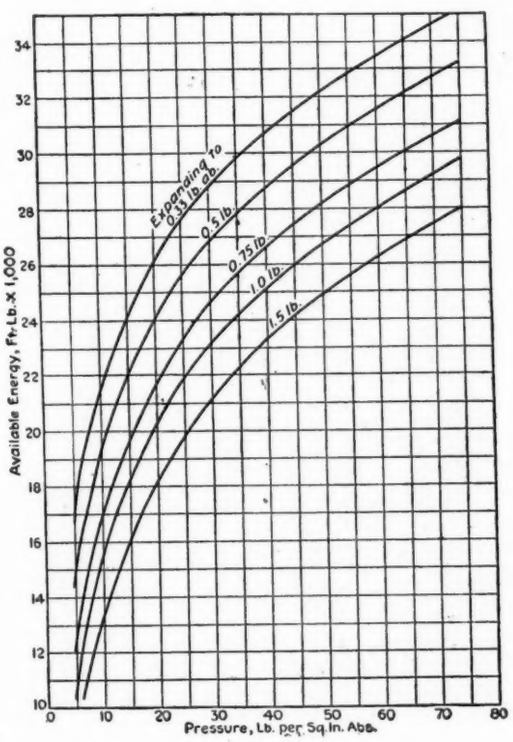


FIG. 5—AVAILABLE ENERGY OF MERCURY VAPOR EXPANDING ADIABATICALLY

shape with the sides slightly curved. These curved sides of adjacent tubes are placed tangent to one another and are welded together at the lower edges, thus taking the place of a bottom tube sheet. The interstices between the tubes hold the mercury. By this arrangement a maximum of heating surface is obtained with a minimum amount of mercury. The pres-

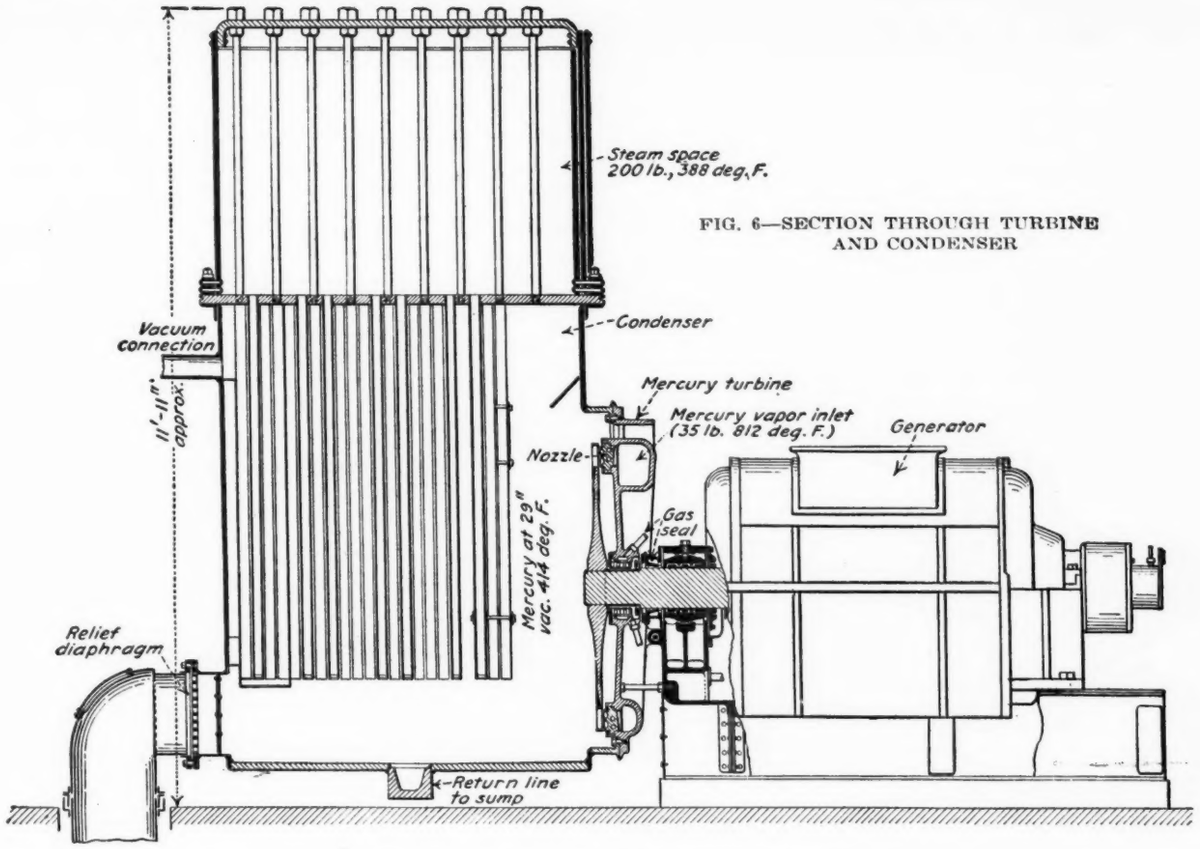


FIG. 6—SECTION THROUGH TURBINE AND CONDENSER

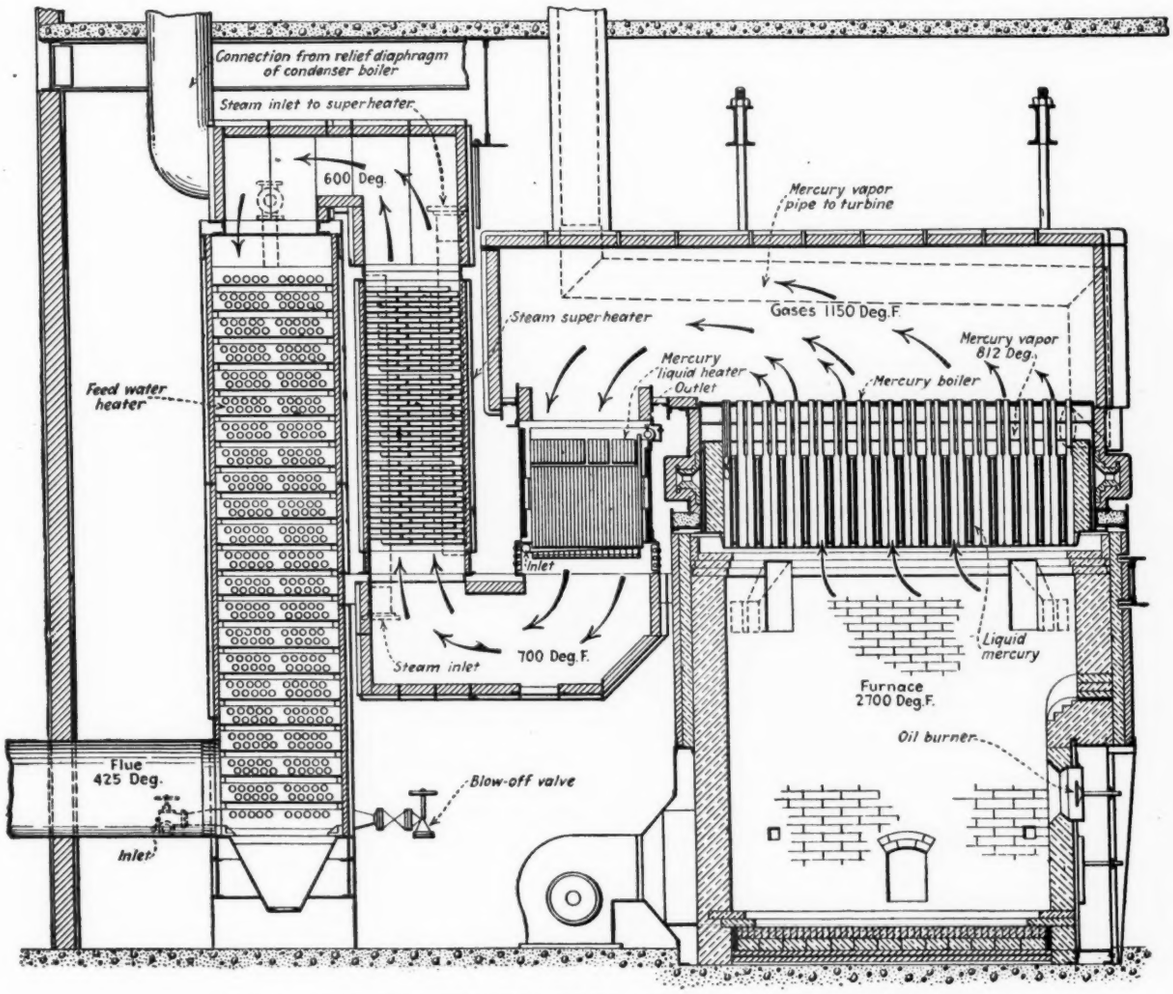


FIG. 7—SECTION THROUGH BOILER, HEATER AND SUPERHEATER

ent boiler holds about 30,000 lb. of mercury and is designed to evaporate 230,000 lb. of mercury per hour. At this rate the turbine would develop 1,900 kw. and deliver about 28,000 lb. of steam per hour at 200 lb. and 100 deg. superheat; although it is understood that the Hartford installation has not been driven to this capacity, as it has been thought expedient to run at reduced load in order that experience with continued operation may be had.

In general design the mercury turbine is not unlike a steam turbine except that the blading is of tool steel to resist the cutting action of the mercury, and the glands are sealed with illuminating gas. The turbine is bolted to the side of the condenser and then welded. When it is found necessary to shut down the unit, the illuminating gas is turned into the system and thus prevents the infiltration of air that might cause oxidization of the mercury.

Like the mercury boiler the condenser consists of a vertical cylindrical shell with the tubes rolled and welded into a single upper tube sheet. The tubes are closed at their lower ends, but are not attached to one another. In this way provision is made for free expansion and contraction.

The mercury sump is also under a gas seal and is provided with an ingenious form of strainer consisting of slanting baffles which project into the liquid and carry a wire mesh on their under sides. Any oxide that may be floating on the surface of the mercury is thus caught by the baffles.

As previously stated, the Hartford installation is merely a step in the development. It has two major limitations. The boiler as constructed is inaccessible for cleaning, and the steam pressure, as governed by the existing station conditions, is relatively low (200 lb.). Thus the corresponding temperature involves a lower pressure in the mercury condenser and a greater drop through the turbine than is desirable for highest efficiency in a single-stage machine. Consequently, another boiler is now being designed. It will be of the inverted V-type in which the mercury will be contained within the tubes and the gases pass over them. The lower headers are so arranged that the bottom part of each can be easily severed with a cutting tool, the tubes cleaned and the head welded on again in a comparatively short time. Moreover, it is expected to install this later boiler where the steam conditions are such as to permit operating the mercury turbine under a more favorable pressure range.

Determining the Area of Condenser Cooling Surface

BY E. C. MILLER

The chart, shown herewith, gives the condensing surface in square feet, required to condense a given quantity of steam with water entering at 70 deg. F. It is based on the following formula:

$$\textit{Condensing surface in square feet} = \frac{\textit{lb. of steam per hour} \times \textit{latent heat of steam}}{\textit{mean temperature difference} \times \textit{heat transfer}}$$

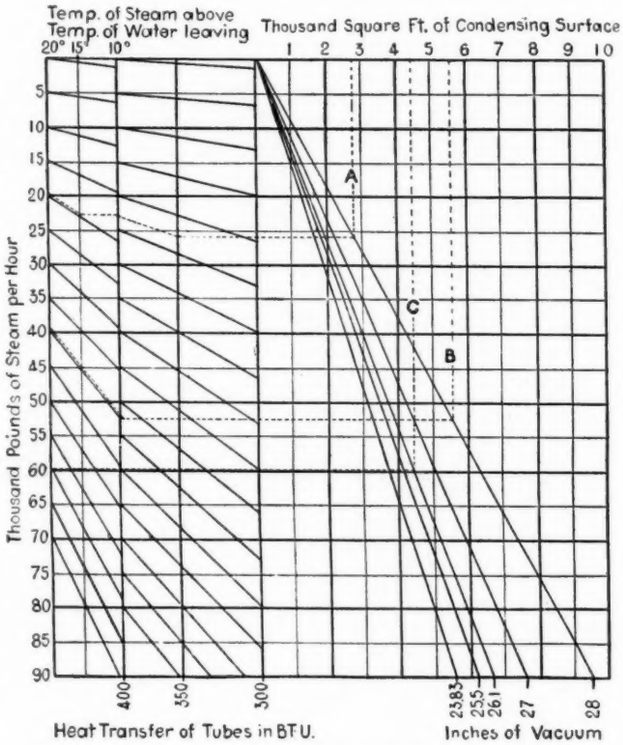
$$\text{Mean temperature difference equals } \frac{t_2 - t_1}{2.3 \log \left(\frac{T - t_1}{T - t_2}\right)}$$

in which T is the temperature of steam, t_1 the temperature of water entering, and t_2 the temperature of water leaving.

Examples are shown on the chart by the dotted lines marked *A*, *B* and *C*. *A* is for 20,000 lb. of steam an hour, at 28 in. vacuum with water leaving 15 deg. below the temperature of the steam entering the condenser, and with a heat transfer for the tubes of 350 B.t.u., per square foot per hour per degree difference in temperature or:

$$\textit{Condensing surface in sq.ft.} = \frac{20{,}000 \times 1{,}035.6}{85 - 70 \times 350} = 2{,}739$$
$$2.3 \log \left(\frac{100 - 70}{100 - 85}\right)$$

B is for 40,000 lb. of steam an hour at 28 in. vacuum with water leaving 10 deg. below the temperature of steam entering and with a heat transfer for the tubes


Temp. of Steam above Temp. of Water leaving
20° 15° 10°
Thousand Square Ft. of Condensing Surface
1 2 3 4 5 6 7 8 9 10
Thousand Pounds of Steam per Hour
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
A
B
C
400 350 300
Heat Transfer of Tubes in BTU.
23.83 25.5 26.1 27 28
Inches of Vacuum

GIVES CONDENSING SURFACE AT DIFFERENT HEAT TRANSFERS AND WATER TEMPERATURES

of 400 B.t.u. per square foot per hour per degree difference in temperature.

C is for 60,000 lb. of steam an hour at 26.1 in. vacuum with water leaving 20 deg. below the temperature of steam entering, and with a heat transfer for the tubes of 400 B.t.u. per square foot per hour per degree difference in temperature.

If the temperature of the water entering the condenser is 60 deg., subtract 14 per cent from the heating surface given by the chart and 7 per cent if the water enters at 65 deg. Also add 14 per cent if the water enters at 75 deg. and 28 per cent if the temperature is 80 degrees.

It may be stated as a general proposition, that the weight of steam evolved by one cubic foot of water in a "steam accumulator" is practically in proportion to the temperature drop. Two things, therefore are essential if any large-scale application is to be made of the steam accumulator as a "fly-wheel" for steam. One is a large capacity for water, and the other is a large permissible variation in pressure.

Power-Plant Problems as Viewed by Designers, Operators and Manufacturers

SIMULTANEOUSLY with the annual meeting of the American Society of Mechanical Engineers there is being held this week in New York, the National Exposition of Power and Mechanical Engineering, where designers and operators of power plants and manufacturers of power-plant apparatus will be brought together with a common interest in view. The time is therefore propitious for a discussion of the problems at present confronting the power-plant field and *Power* asked several representative designers, operators and manufacturers to give concrete expressions of their views as to what is most needed, what are the shortcomings and apparent difficulties of existing methods, machinery and material and, from the designers and manufacturers, what are their principal difficulties in getting at and satisfying the needs of their patrons. The responses are contained in the following symposium.

Saving Fuel in the Modern Power Station

By Thomas E. Murray
Designing and Construction Engineer, New York

The subject of fuel saving should be, and probably is, the leading topic among power-station engineers today. The term "B.t.u. per kilowattt-hour" is heard today where up to a short time ago no one ever thought of increasing the efficiency of a plant.

Fuel in the modern power station makes up approximately 75 per cent of the production cost, and every means should be taken to reduce this item with due thought for the expense of obtaining the saving. In many cases I believe that the saving does not warrant the expenditure of the money that is being invested. This is looking at the problem merely from the dollars and cents viewpoint. However, we should endeavor to conserve the nation's resources so that future generations may not be deprived of the comforts and facilities that we have today.

I believe that the most logical place to attack this problem in the modern central station is to reclaim the heat of the flue gases by means of air heaters rather than economizers. The introduction of stage heating of the feed water by means of steam bled from the turbine has materially decreased the economic use of economizers. The air heater is being rapidly introduced into stations in this country, but up to the present very little actual information is available as to its performance. Many designs have been proposed and some installed, but we have little data on this very important subject. I think that we should attack this problem in a vigorous manner, as I believe that with our present knowledge of steam cycles we can obtain the maximum economic results in efficiency by means of air heaters and stage bleeding in a station that is otherwise also well designed.

Regarding difficulties in obtaining satisfactory materials, I believe that for some time past the most serious trouble has been that of obtaining satisfactory steel for high-pressure service. Steel valves and fittings are quite essential to the modern station being built today, and it is with considerable difficulty that we have obtained good steel castings. This trouble is not confined to any particular manufacturer or manufacturers, but seems general throughout the industry. I believe this should be forcibly impressed upon the manufacturers. If these parts can be made of forged steel, a great step forward will have been accomplished.

Co-operation in Designing a Power Plant

By Charles T. Main
Consulting Engineer, Boston

There are three principal groups contributing to the success or failure of power-plant work: The designer of plants, the operator, and the manufacturer of equipment. The men in each group are generally different in type of mind and in training. It is seldom that one man can approach the best in all three, or in even two of the groups. Much of the power engineering in industrial plant work can be traced to a failure to realize this fact and to expecting that, because a man is a good operator or a good salesman, he will be able to do good design work, for which his experience may not have fitted him.

Another common source of trouble seen in such plants is the lack of experience in visualizing the whole problem, as to both present and probable future conditions. Engineers of broad training and wide experience have learned the necessity of constantly keeping before themselves a broad view of the whole problem, while those of less experience or with sales necessities are likely to be content to attend to the immediate details and let the general problem take care of itself. The experienced designing engineer should, and usually does, keep constantly before him the question of fixed charges on a development, including interest, depreciation, maintenance, insurance and taxes, in addition to the operating charges, when considering new expenditures, so as to determine not what may be the most economical operating expense, but what the total yearly cost will be, including all fixed and operating charges.

In designing a plant the consulting engineer should work with the operating engineer wherever possible, as the operating engineer always has valuable information about his plant. Ability to work with the plant force is an important qualification of a consulting engineer.

The manufacturer of apparatus should know more than anyone else about its performance and limitations. It is important that he should be given a clear and accurate knowledge of all the conditions under which his apparatus will be used, as well as an understanding of the results to be obtained. Where possible, these conditions should be such as can be fulfilled by the usual commercial apparatus. An engineer in close touch with the manufacturer will usually be able to accomplish this. Where this is not possible, the apparatus must be made to fit the conditions. Many troubles can be traced to the purchaser's "being sold something just as good." Most

of the engineering work today is good. Probably most of the trouble that is experienced results from the owner's "being sold" instead of "buying."

Designing engineers of broad experience, who will work with the operating engineer when designing plants, so that the manufacturers of apparatus will be given a clear understanding of the conditions under which the apparatus will be called upon to work, will correct most of the troubles experienced in some of the engineering work of today.

Heat Balance and Higher Steam Pressures

By C. W. E. Clarke
Power Engineer, Dwight P. Robinson & Co., New York

Central-station practice in the last few years has undergone some rather rapid changes in most of its phases. It has always been an ever-changing art, but the recent developments have made it necessarily more so.

It was only a few years ago that little or no attention was paid to heat balance other than to take precautions that excess exhaust steam was not rejected, but was all absorbed in the feed system. Heat balance in the present-day station is infinitely more complicated but at the same time more efficient and reliable. House turbines, much in vogue two years ago, are rapidly being replaced by auxiliary generators attached to the mainshaft of the turbine, feed-water heating being accomplished by bleeding the turbine at several stages. This present-day type of heat balance implies the exclusive use of electrically driven auxiliaries if proper efficiency is to be obtained.

The question of increasing steam pressures is receiving much attention, and with it inevitably go the problems of turbine steam reheating, the use of compound units and the use of heat-reclamation systems on the flue-gas side of the boiler plant.

The development of pulverized-fuel firing and the utilization of waste gases for preheating combustion air, a feature that works so well with pulverized-fuel firing, are rapidly revolutionizing the fuel-burning end of the problem and in the largest stations make the use of larger boiler units attractive.

In the whole ever-changing subject it should be borne in mind that no development should be made toward improving plant economy—that is, heat consumption per kilowatt-hour delivered—unless it is clearly demonstrable that the greatest return for the dollar invested will be effected and, further, that the reliability of the plant in so far as continuous operation is concerned is not endangered.

A Study of All Factors Essential

By Peter Junkersfeld
McClellan & Junkersfeld, Consulting Engineers, New York

The following are some of the things necessary to overcome the shortcomings and operative difficulties of engineers and operators of power plants and manufacturers of apparatus:

1. More open mindedness and thoroughness and less tendency toward decisions based on preconceived notions, prejudices or superficial information.

2. Better knowledge and better application of the fundamental economics in the design and in the operation of power plants and in the manufacture of apparatus for each condition or set of conditions. The cost and quality of all undertakings and all service are greatly influenced by basic materials, load factor, capacity factor, fixed charges on investments and on working capital, peak demands for labor, material and money.

3. Better load factor on designing, manufacturing and construction, personnel and facilities in order to secure lower cost and better quality. This means looking ahead farther and more thoroughly. Load factor is usually fixed by the buyer, the capacity factor by the seller.

4. Avoiding the kind of chance that usually results in rush and overtime work and in peak demands for material and labor. We should keep in mind that average building trades labor rates, for example, are about two and one-half times those of 1913, while interest and dividends combined, at present are only on the order of 25 per cent above 1913. It will frequently be much more economical to reach a decision and start work a year earlier than pay for extra and overtime work.

5. Better appreciation that the best ultimate interest for all in the power industry is in the direction of apparatus and plants that afford the best ultimate service and economy to the public.

The bringing about of all these desirable things is quite another matter. It is evident that the power industry has ample opportunity to "put its house in order" as well as the world at large.

Individuals in the power industry need a better understanding and observance of sensible engineering and business ethics, more consideration of the other fellow's problem and a realization on the part of each individual that in the long run it pays to play the game properly in thought, word and action.

Problems in Industrial Power-Plant Design

By Albert C. Wood
Consulting Engineer, Philadelphia

So much progress has been made in the last decade in the development of power plants and power equipment that one might wonder if most of the shortcomings and difficulties of earlier days had not been met and overcome. But new developments, involving higher pressures and ratings, concentrated production and increased efficiency have brought new difficulties, calling for improvements in design, materials and construction. However, with the intense co-operative action now happily going on between engineers and engineering organizations, our technical societies and committees and the staffs of our large manufacturing organizations, we may predict that the existing difficulties will be solved and that the next decade will record quite as marked advances as have taken place in the last ten years.

In the power plant of the average industrial establishment and of some of the larger enterprises the principal shortcomings are due to the design and methods more than to the machinery and materials. The principal difficulties are to be found in the boiler room, where inadequate provisions for working space, light and ventilation are common, making it hard to keep the plant in an orderly, clean and efficient condition and increasing the difficulty of getting good men to stay on the job. Inadequate combustion space and draft and lack of suitable means for handling coal and disposing of ashes are

other common faults of such plants. In the engine or turbine room working space, light and ventilation requirements are frequently disregarded, and insufficient headroom is allowed in basements for condensers, piping, etc., while frequently the power units chosen for the work are unsuited to the peculiar conditions of the case.

In the more modern and up-to-date plants the design of the boiler settings and the materials and methods necessary in their construction to resist the high furnace temperatures and overcome erosion and clinkering difficulties, continue to engage the earnest thought of the power-plant engineers. The furnace problem in its various phases is in fact one of the most important with which we have to deal. It would seem that we must have reached the limit of combustion-chamber dimensions, and in order to reduce construction costs, not alone of the boiler settings but of the boiler house as well, also maintenance costs, we may be led to discover some way by which the necessity of larger furnace volumes can be avoided and brickwork maintenance and slagging difficulties reduced. With preheated air supply the refractories problem will become more difficult unless water screens or other protective means can be successfully employed or some radically new type of boiler construction can be devised to meet the situation. In most boilers the maintenance of tight baffling is one of the serious problems; particularly is this the case in boilers with transverse baffling.

One other difficulty I might mention in ordinary setting construction is due to the difference in the size of the red brick and the firebrick of commerce, and one wonders why brickyards near large industrial centers might not be induced to make a special size of red brick which would lay up with the standard size of firebrick to better advantage.

The equipment employed in connection with the discharge and disposal of ashes in power houses is still not all that could be desired, and perhaps never will be, owing to the nature of the material handled.

More reliable and accurate and less delicate apparatus for weighing coal and water and measuring and recording steam flow and the temperature and composition of the flue gases is much to be desired. Good work has been done by manufacturers of such equipment, but the present state of the art leaves much to be desired. Combustion-control apparatus as now built and installed will also stand development and improvement. Perhaps the difficulty with this equipment has been that it has been an appendage rather than a part of the main power-plant equipment.

More efficient and more sturdily built auxiliary engines and turbines are much to be desired. Often an important main unit goes out of service on account of the failure of some cheaply constructed auxiliary.

While the better makes of piping materials, valves, traps, etc., are fairly satisfactory for existing steam pressures and temperatures and for other services about power plants, higher steam pressures and temperatures will necessitate radically improved construction.

The principal difficulty that an engineer meets with in getting at and satisfying the needs of his client, is ordinarily attributable to the unwillingness of the client to pay for such investigations and tests as are necessary to develop the facts. Frequently the plant records are of little value, and often the client has no very broad vision as to the future, and sometimes when he has, he is not willing to build against it, preferring to temporize or to use his money in some line of his business.

Collective Effort in Power Generation

By W. H. Balcke
Head of Station Betterment Division, Stone & Webster, Boston

Thanks to our national societies and the technical press new engineering knowledge and experience, by whomever gained, are quickly and almost universally made available, but unfortunately, the mere existence of greater knowledge does not always assure its prompt application to practice. To realize this result, we must develop the relation between all individuals concerned which will most effectively focus this new knowledge and experience upon the specific and complex problems involved, not only in the design of power stations, but in their operation as well. Those who have been identified with these problems must concede that the desired spirit of co-operation has by no means been entirely lacking; in fact, the pronounced advance in design and marked improvement in station economy shown within the last few years could not have been accomplished except by a high degree of such co-operation. It is for continued progress that this relation should be still further fostered and developed.

The manufacturer, in constantly building equipment for the same general purpose, finds in each new machine an opportunity to apply the improvements suggested by research and test. Similarly, the station designer is enabled to make improvement in selection and arrangement largely through his constant association with new projects. On the other hand, the station operator is in many instances required to devote his energies exclusively to the particular plant under his charge. Happily, there is a growing tendency for operators to study conditions in other plants, and this should be encouraged so that they may be better qualified to contribute the assistance that they alone can give. Plainly, the operator is the final and authoritative tester of both the equipment and its arrangement, and it is primarily from his report that both manufacturers and designers must judge their own success.

The direct responsibility for obtaining the desired collective effort naturally rests with the designers, in view of their function. The possibility for improvement therefore lies principally in broadening and extending the assistance which the other parties give to the designers and in an open-minded attitude on the part of the latter toward the suggestions advanced. Verbal conference and discussion direct with the manufacturers' engineers and with the operating engineers offers a much more effective method of obtaining the desired information and suggestions than does discussion by correspondence.

The interest of the designers and manufacturers in a generating station cannot cease upon the mere completion of its construction, as this means the neglect of an unequalled opportunity to compare the actual results with those anticipated and to secure highly valuable data for guiding their future practice. Furthermore, it is important that the operating forces be thoroughly informed regarding each new feature to insure their taking full advantage of all refinements of design. This can best be accomplished by an experienced operating engineer acting as the direct representative of the designers during the preliminary operation of the station.

Collective effort is a valuable influence in reducing the cost of a station as well as in improving its reliability

and economy. The conception that the best engineer is the one who can produce the most for a dollar is the true conception, and progress in the art has without question been fostered rather than hindered by the requirement of limitation in construction cost. However, with the increasing demand for greater economy, more and more thought must be given to the problem of attaining the desired result without unnecessarily increasing complexity with a corresponding increase in cost.

Any innovation, no matter how promising, is experimental until proved in practice. While the engineers may well be proud of their record of accomplishments, they should not forget that there is another and still more important contributor to progress, the owner, who has encouraged every forward step and assumed the financial risks involved.

High Efficiency Versus Dependability

By W. L. Abbott
Chief Operating Engineer, Commonwealth Edison Co., Chicago

In the urge for lower investment costs and higher efficiency in power-plant equipment, manufacturers and designers have, in some particulars, been required to push their developments to extremes not warranted by results. The amount of time that equipment is out of service for repairs and the cost of repairs more than offset the savings in efficiency secured at such cost. And while older equipment, of more conservative design, is less efficient than the new, the number of hours in a year that it is operated is far greater than would be the case were the new equally serviceable. For example, grates have been increased in size and draft has been increased in pressure to a degree that renders furnace temperatures and erosions most destructive to furnace linings; and although an increase of boiler rating from 200 to 250 per cent may appear to be a saving in equipment, the apparent saving vanishes if the boilers must be out of service 20 to 25 per cent of the time for furnace repairs.

Economizers, by effecting a saving of from 5 to 8 per cent of the heat of the fuel, may seem to fully warrant their cost, but if this saving is effected by having such a low temperature of gases leaving the economizer that it is accompanied by the condensation of acid on the economizer tubes, with a resulting high rate of corrosion, much of the saving in fuel disappears in the cost of repairs.

High-speed turbines occupy relatively less floor space than low-speed turbines, cost less per kilowatt of capacity and have higher efficiency, but the delicate blades of such a turbine run at an almost incomprehensible velocity within narrow clearances and, subjected to vibrations and tensions, are always near the edge of endurance; and when the smallest of these delicate parts fails, the whole unit may be placed out of service for weeks if happily it be not entirely wrecked. The frame and revolving parts, although lined up with micrometer exactness when cold, are subject to gross and unequal distortions when subjected to the great range of pressures and temperatures to which steam is subjected on its way to the machine.

A piece of power-house equipment that has to be coaxed for an hour before it will take its load, is liable to be sometime put to work without sufficient coaxing but with extreme hazard to itself and its surroundings.

In the quest for higher efficiency we have lost much of the dependability in which we formerly took such pride. It is indeed time to ease up on the forward drive while we consolidate the ground already conquered and regain our reputation for reliable service.

Shortcomings and Operating Difficulties with Existing Methods

By N. E. Funk
Chief Operating Engineer, the Philadelphia Electric Company

The following thoughts should not be considered as a wholesale condemnation of the art as it exists. My feeling in general is that we have probably progressed a little too rapidly so that the manufacturers of fabricating materials and machinery have not been able to obtain operating experience of their wares on which to base their designs, which, when called upon to fulfill even more stringent conditions than the preceding ones, they are unable to do. This has got us into a place where our experience is lagging considerably behind our construction, with the result that numerous errors are propagated for some time before there is sufficient evidence collected to force a change in design.

However, the thing that does not require this experience and which apparently is not appreciated by the designers is that the average type of power-plant man handling machinery is not a technically trained man and that he is more or less rough. Much power-plant apparatus is designed theoretically strong enough to perform the duties for which it is intended but not strong enough to withstand the man-handling it receives. Not only do designers fail to appreciate this, but their designs do not allow for slight flaws in material. Often a little more liberal use of material would increase the life of apparatus by preventing breaks due to a slight flaw.

The problem of preventing erosion by both steam and water apparently has not been satisfactorily solved. Even the underlying principles to prevent this are unknown or, if they are known, are not applied by the designers. This applies to turbine blading, steam valves and piping, boiler-feed pumps—in fact, almost any piece of apparatus through which steam or water passes.

One of the outstanding difficulties at present is that of obtaining satisfactory steel castings. Manufacturers will declare that they have no trouble with high temperatures and high pressures in valves, fittings or other cast-steel devices for carrying steam or oil distillation vapors. Nevertheless, the experience seems to be universal with manufacturers, that when their apparatus is purchased these troubles do develop, and apparently the wild proclamations of the manufacturers are more in the manner of advertising than in the statement of facts.

While the designer is paying more attention to the proper lubrication of moving parts than was the case in the past, there is a tremendous amount of room for improvement not only in so arranging the design that operating temperatures are reduced with the consequent reduction in energy loss, but in giving heed to the conservation of the lubricant. Improper design has almost as much to do with high oil bills as the use of an improper lubricating medium.

In many designs parts are incorporated that are

expected to take up wear. Unfortunately, it is usually necessary to dismantle the apparatus completely to attain this aim, when in many cases a slight rearrangement would make adjustment possible with considerably less maintenance expense.

I believe one of the greatest needs so far as the purchaser is concerned is a proper inspection department in the manufacturers' organization. No matter how conscientious the manufacturers' inspectors may be, if the proper inspection methods are not installed, they may be unable to detect the faults that should be caught before shipment. Only too often, visual inspection alone is depended upon.

In many cases the manufacturer makes the main part of his apparatus and then buys the automatic control, magnetic brakes or similar devices from some outside manufacturer. In many instances this apparatus is purchased from a salesman without any engineering co-operation from the manufacturer of the parts, and when the complete apparatus is put on the market it is found that serious trouble exists from improper application, probably due to the efforts of a purchasing agent in conjunction with a salesman. I feel that all assembled apparatus of this type should be given careful thought by the manufacturers' engineers whose parts go into the assembled whole, as the result may not only condemn the complete product but reflect seriously on the manufacturer of the parts.

These criticisms do not apply to any one manufacturer, but are fairly universal, one or more of them being applicable to practically every manufacturer's apparatus.

Some Needs of Power Plant Operators

By N. G. Reinicker
Superintendent of Operation
Pennsylvania Power & Light Company

A great help to the industry from the point of view of both the power-plant operators and the manufacturers of power-plant apparatus could be obtained through a well organized research department. This would have the advantage of relieving each company of its burden of investigating each problem separately. As actual research in the power plants is now carried on, the company that goes ahead and develops a new method of operation usually does so at great expense and bears the expense for the whole industry. A quite similar situation exists in the manufacturing field. It is recognized that a great deal of research is done by the various committees of research societies such as the N.E.L.A., A.S.M.E., A.I.E.E., etc., but no experimental work on a large scale is attempted. This would necessitate one or more central research laboratories and would be quite expensive, but if it were supported by all parties interested, including every operating company and every manufacturer in the country, the cost to each would be only a small portion of that which they now pay for unorganized research.

Referring to materials that are needed, it is believed that the greatest need at the present time is for some metal that will stand high steam temperatures and pressures at the same time. By this is meant pressures from 500 to 2,000 lb. and temperatures of 700 to 1,200 deg. Power-plant designers at present are limiting their temperatures to about 700 to 750 deg. F., feeling that there is no metal that will stand up at higher temperatures. Since it is possible to design equipment to withstand high pressures by simply putting in more material, the greatest need is for material that will withstand the high temperature. Also there is more advantage in going to a high temperature than there is in going to a high pressure.

There is need for a material to stand up under high temperatures for use in the manufacture of soot blowers, since it is fairly well established that the soot blowers at present manufactured will not stand up in that section of the boiler setting where they are most needed.

Also, there is need for a refractory that will stand up under high furnace temperatures such as will be necessary when high steam pressures and temperatures are obtained. This is especially true in the case of sprung and suspended arches over forced-draft traveling-grate stokers. Refractories as at present manufactured are irregular in shape due to the antiquated methods used in most of the factories. It is felt that it is entirely possible to manufacture better firebrick than are now being manufactured if the necessity for them is sufficiently realized by all power-plant operators and sufficient pressure is brought to bear on the manufacturers.

Since there is no other item entering into power-plant costs as great as the fuel item, it is the object of all wide-awake operators to secure the best fuel economy possible with the equipment operated. There is no single item that indicates good or bad combustion conditions as well as the CO_2 content of the flue gases. A CO_2 recorder that could be absolutely depended upon by the boiler-room operators would be a wonderful help to the industry. It is recognized that there are now on the market a number of CO_2 machines, each one of which the manufacturers claim is as near perfect as it is possible to make it. However, the experience of a large number of power companies indicates that there are very few who have been completely satisfied with any CO_2 recorder, and I believe that I am expressing the opinion of the majority of the power-plant engineers in the statement that there has not yet been developed a suitable CO_2 recorder.

Pulverized fuel is rapidly becoming established as the most economical fuel under a great many conditions. The methods of pulverizing bituminous coal have advanced to the point where good economy can be shown with the machines now being manufactured. However, this is not true in relation to pulverizing anthracite coal, and there is need for development of a suitable pulverizer for anthracite slush and river coal which will put pulverized anthracite on a competitive basis with pulverized bituminous.

Committees Render Important Service

By R. D. DeWolf
Chief Operating Engineer, Rochester Gas and Electric Corp.

There are specific problems which demand solution, particularly in the field of our new power-plant developments employing higher pressures and temperatures. Not only in connection with the development of these new advances in power generation, but also in connection with our everyday problems of operation, one of the outstanding accomplishments of the last four or five years has been the marked increase in spirit of co-operation and mutual helpfulness that has been developed between

the manufacturers and the power-plant operators, owing in a considerable degree to the various committees of our associations such as the N. E. L. A., A. S. M. E., A. I. E. E., etc.

These committees have become more and more the mouthpieces of the industry that they represent and, as such, can give a condensed and comprehensive expression of the industry's needs for new developments. Such an expression of the composite thought of a large number of experts in the operating field results in pointing out to the manufacturers and designers the direction in which the user feels the development should proceed.

Another useful function of these committees is that they form a sort of clearing house for complaints and suggestions for improvements of existing apparatus. These committees compile and digest such complaints and make every effort to make the criticisms as finally transmitted to the manufacturer constructive rather than destructive, substituting a spirit of mutual co-operation and helpfulness for the feeling of antagonism that has too often existed in the past.

With this spirit of mutual helpfulness and co-operation constantly fostered and built up through the national committees, I do not think we need feel anxious about embarking on new developments that give promise of improving the efficiency and reliability of our service. The difficulties that are encountered in such developments will be overcome, and a solution satisfactory to both the manufacturer and the user will be worked out, through a mutual sharing of the responsibilities and obligations.

Operating Standards Needed

By F. M. Gibson
Mechanical Engineer, American Sugar Refining Co., South Boston

One of the principal difficulties experienced by the operating engineer is the lack of comparable operating data and of standardized nomenclature. In other words, we are not speaking the same language; a term used in one locality may have an entirely different meaning in another locality. Many industrial plants are keeping records that are really a continuous test, but these are of limited value when quoted, for the reason that other operators do not know what items have been included in the general result or how the computations were made. Recently, very high boiler efficiencies were quoted in two tests. Upon investigation it was discovered that in one instance the performance of the integral economizer was credited to the boiler and in the other instance net B.t.u. were used instead of gross B.t.u.

There should exist a set of standard definitions of operating terms and a standard method of calculating and recording performances of continuous operation; all of which should be sponsored by some one of our national engineering societies. No one questions the value of the acceptance test and its need of standardization; witness the nineteen acceptance codes being formulated by the A.S.M.E. Power Test Code Committee. Every argument that is advanced in favor of the acceptance code can be presented with equal force in favor of continuous test codes. A piece of equipment is purchased on a guarantee that is judged by an acceptance test, run under abnormal conditions for a fractional part of a day. Every effort is made to secure the very last per cent of efficiency. Then for years after that fractional part of a day and under very different conditions, this equipment is consuming power or its equivalent, fuel, and few people know whether it is operating 5 per cent or 10 per cent below the average efficiency that it should attain. If they do know, and there are some who do, they have no standard method of recording it so that the information is comparable or readily available to others interested. When the operating engineer has a comparable way of recording his performances and a uniform means of expression, he will produce better results, and when he wants to increase or rebuild his plant, he can present dependable data in an understandable way to the consulting engineers and manufacturers.

Another of the operating engineer's difficulties is in getting the manufacturer of equipment to realize that sometimes the operator is right when he states that his conditions are unusual. This is particularly true in non-condensing plants where all the exhaust steam can be utilized in manufacturing processes. In such a case the prime mover is used practically as a reducing valve, and efficiency is synonymous with steam rate. A moderate increase in efficiency is therefore not of major importance if all of the exhaust steam can be utilized. Instead of proposing and urging equipment of unusually high efficiency, the manufacturers should propose and urge equipment of possibly a little less efficiency, but more capable of low maintenance cost and greater continuity of service.

Closer Co-operation Between Manufacturer and Operator Desirable

By W. G. Diman
Supt. of Power, Amoskeag Mfg. Co., Manchester, N. H.

Some form of association consisting of consulting engineers, designers, manufacturers of equipment and operating men should be promulgated in which an exchange of views and experiences in power development as well as apparatus could be disseminated. This would be helpful to the designer and engineer as well as to the manufacturer. The knowledge gathered should be placed in such form as to be easily obtainable. Much work has been done in the past that has, in time, been lost. The developments of machinery result to a large extent from research combined with operating results and experience. The perfect machine is only the result of design coupled with years of operation. Most manufacturers endeavor to keep in touch with operating results, either through salesmen or field engineers. The user is in the best position to know the possibilities and shortcomings of the apparatus in his charge. The industries that make the greatest progress are those in which co-operation replaces suspicion and where energy is directed into productive channels rather than working on protecting trade secrets. Manufacturers that co-operate in obtaining and disseminating knowledge of common value, find their reward in many ways. Unfair competition grows less and competitors come to know and trust one another. There are types of consulting engineers, operating men and manufacturers of equipment who are so arbitrary in their dealings that there is little wonder one is opposed to the other. Most men are ordinarily glad to know of improvements, and often materially assist each other by friendly criticism and suggestions. Remember that no one knows it all.

If the representative of a manufacturing concern is all that he should be, anyone interested in his product should be benefited by an interview with him. When an engineer knows his problem and the manufacturer's representative is familiar with all phases of his product, then it should not take long to find out the merits. When bluff is met, it generally leads to failure where frankness and co-operation would have resulted in success. Some salesmen sell with the idea of making a sale regardless of the merits of the case, and in some cases apparatus is sold knowing that another form of apparatus would better fit the case. This is not only true of apparatus but covers, in some cases, a too intensive sales effort from central stations where use is urged for purchased power against the best engineering and economical practice for the particular plant.

Guarantees should be broad enough to meet the actual working conditions. This would lead to less unscrupulous bidding against honest engineering. Only a small percentage of machines are tested after installation under operating conditions.

Manufacturers should always hold to quality and make the apparatus the best they know how. Nothing should enter into the manufacture of the apparatus for price competition. It injures the manufacturer, the designer and the operator. In the purchase of the apparatus the consulting or operating engineer should be the one best qualified to judge and no one not knowing the exact use of the apparatus or its operation should specify same. Sometimes, but not often, factors other than the merits of the equipment dictate where goods are to be purchased. The purchaser does not pay for the equipment, but for the results he wishes to obtain together with service. If the operator does not operate the apparatus to the best advantage, he is dissatisfied. In some cases the operator does not fully understand the possibilities of the apparatus. Future manufacturing business depends on the results obtained with the equipment. If satisfactory, it will aid in selling itself. Nothing is lost from a manufacturing standpoint in having the equipment operate to its best advantage and this can be obtained only through service and co-operation.

The average operating force may not be competent to design a new plant, but they can furnish the designer with valuable information and point out changes that will increase the ease of handling and decrease the operation and maintenance costs quite differently in many cases from those on which plans and purchases are based.

Equipment and Personnel as Factors in Industrial Power

By E. S. Cooley
Inspector of Steam Plants, International Paper Co., New York

In a great many industries where the proportion of power used or steam required for manufacturing purposes is a large item, as is the case in the manufacture of sugar, rubber, steel, paper, chemicals, etc., there is a lamentable lack of appreciation of the value of correct information as to the amount of fuel used, the results obtained in the production of the power or steam requirements and, in general, the cost of such production. There is also a lack of correct and specific information as to the use of such power or steam in the manufacturing work itself.

This condition has arisen in many cases because the principal interest was centered in production in volume, rather than in a detailed understanding of the costs in all departments leading to the final cost of the product. It is true that sometimes the power or steam requirements are small compared with the complete cost of production; but in many other instances these are a considerable item in the final cost, and in some cases the amount of money spent in the course of a year for fuel and power reaches large figures, so that a reduction of a small percentage in this item would amount to an important sum in dollars and cents.

It is necessary for those charged with the economical production of such requirements, to have at hand complete and correct information as to the actual results being obtained both in the generation of the necessary power and steam, and with regard to the use of this throughout the manufacturing process, before they can intelligently proceed toward economy in the production and use of the power and steam required.

Frequently, there is serious lack of co-ordination between the designing and operating sides of the problem. Many designers have a point of view that is based largely on the designing or drafting room view of the question, and they are not adequately informed as to the actual operating necessities. In many cases they are not prepared to recommend the most economical form of equipment or are unable to secure authority for the additional expense involved in installing equipment of this character in place of much less economical equipment which may be already available.

The final result is that many of our industries having large fuel and power bills, appear to me to be following today operating methods that have been obsolete for many years, where modern equipment would pay a remarkable return on the expenditure necessary for its installation. The latter would only be true, however, where such equipment is installed with a full understanding of the operating requirements to be met.

When modern and economical equipment is installed, it should be accompanied by the necessary recording and indicating instruments to permit an exact determination of the results secured in the production of steam or power, and similar instruments should be installed at the point of use so that the actual factors involved may be apparent.

It is entirely possible for the best results in the production of steam and power to be offset by an uneconomical use at the point of application, and it is also possible for the anticipated beneficial results to fail of realization when the best equipment is put in the hands of operators who are not adequately educated and trained in its use. Sometimes it seems to be taken for granted that a man who has had many years of experience as a fireman, engine runner or switchboard attendant, must necessarily be qualified to handle all the power and steam problems, and that if such a man may be obtained cheaply with a fair assurance of continuity of supply of steam or power, the needs of the situation can be adequately met.

I have recently been much impressed by facts that I have learned concerning the generation and use of power and steam in some of the European countries. It is true that in some cases expensive installations are involved, and a very high overhead cost is incurred in the operating and particularly in the supervising personnel; but the results reached in some instances seem almost revolutionary when the final cost is considered.

Present and Future Possibilities of Power

By David B. Rushmore
Chief Engineer Power and Mining Dept. General Electric Co.

As an essential part of our industrial life, we depend upon power for light, transportation, communication, heat, and chemical reactions. In fact, power is but an expression of life itself, and since energy and matter are no longer distinguished, the question of power and its limitations becomes much broadened.

It is well to ask ourselves regarding the particular object which we have in view in all this power development, and to see clearly that it finally is for the object of relieving human life of drudgery, and to give human beings freedom for the higher development—this is really the ultimate aim of our conquests in the world of power.

The present growth in the use of power and the rapid improvement in the efficiency with which energy in useful form is obtained from the primary sources naturally raise the interesting question as to final possible limitations—limitations in magnitude and limitations in efficiency. Many brilliant inventive minds are now working on the problem of improving present methods, as is evidenced by the development of the mercury turbine, the wonderful improvement in internal-combustion engines and the utilization of higher steam pressures. To make available the energy bound up in atomic forces is still the dream of scientists, and the direct production of electricity from fuel still remains unsolved from a practical viewpoint.

Without attempting to answer the questions regarding the ultimate efficiencies and magnitude of power development, we can be sure that the next century will see tremendous increases in the quantities of power used. There will be great increases in efficiencies, in methods and many new and wonderful means of utilizing the stored up energy given us so bountifully by nature.

Reliability a Necessity

By E. H. Sniffin
Manager of Power Section, Westinghouse Electric & Manufacturing Co.

The power plants of the country are a great public agency. They have become so necessary to the daily lives of our people that we can think of them only in terms of public demand and public necessity. They must be ready to serve.

The large manufacturing organizations which turn out the machinery, apparatus and devices that make this service possible, are therefore in a very real sense public-service companies. Their managements know this, know it only too well, and no problem concerns them more than the need of getting their thousands of men, many of them not in direct touch with the public, to fully understand the real meaning of public service.

In this partnership between the utility company and manufacturer there can be no compromise on one point at least, and that is on the quality of the apparatus, the thing that spells reliability. Truism though this is, and so obvious as hardly to be worth saying, it will not hurt the designers and the shop people to hear it every day, and the buying and selling would sometimes be better done if this very real fact were stripped of its academic dressing. This will be corrected as engineering and mechanical considerations become an increasing factor in the purchase. No one would say that the apparatus today is good enough. The shortcoming is not in efficiency, for that is fairly keeping pace with the economic demand. The real trouble is the interruptions to service due to inadequate design or materials. If the utility companies are to continue their record of progressively lower charges for their service, they must not only find relief from their expensive outages, but they must be able to work their apparatus much harder than they have before. The factors of first cost, and even of efficiency, will be small indeed compared to the factor of availability.

No responsible machinery or apparatus manufacturer would think of impairing the quality of his product in the attempt to save on his cost. Apart from his ideals and the pride that goes with his kind of work, he knows what it costs him to have things go wrong, and he dare not risk it. The deficiencies in his product are usually the result of lack of knowledge, or of the undeveloped state of the art. In steam work especially, he belongs to that large fraternity of able engineers who hold divergent views and have been unable to agree upon standards of practice. We are at the threshhold of higher steam pressures and temperatures. Boilers, piping, fittings, turbines and auxiliaries must meet this new requirement, for we must reduce the operating cost.

Higher voltages are coming into use and new distribution problems are appearing with the more extended use of electric power. But again, we need above all things more reliable plant equipment, and every means taken to insure greater reliability. One might well wonder if the industry wouldn't be further ahead if for a period of time all new designing were directed to the sole object of increased reliability in the things that exist.

The best results lie in the concerted efforts of the user and the manufacturers. They must meet frequently. No committee work could be more important than a periodic review of the operating records, an agreement upon the facts, and so far as possible a mutual remedy worked out to cure the weak features. Already considerable work in this direction has been undertaken by several of the large utility associations, and with good results. It ought to increase, and it should have the support of every operating company and of every manufacturer in the country.

Stokers Versus Personnel

By R. Sanford Riley
President, Sanford Riley Stoker Co., Worcester, Mass.

In the combustion field we think we have problems not found in any other line of business. Our basic fuel, coal, is a product of nature that is consumed in a raw state and therefore has all the variables incident to its formation. No two veins of coal are exactly alike, and there are even variations in the same vein, not to mention the variable factors in connection with its mining, transportation and preparation for use.

For this reason the personal element in connection with combustion is a more serious factor than in connection with other lines of work where the variable elements are largely confined to the personnel. No stoker is automatic in the sense that it automatically maintains correct fuel bed conditions. Nevertheless, stokers have

been developed to such a degree that high efficiency is obtained. Different kinds of coal require different kinds of stokers, but they all require skillful handling in order to show maximum efficiency.

With increased skill in handling, stoker manufacturers are taking greater liberties with the refinements of design and regulation. A few years ago we did not dare put on anything that required much skill because of the danger of misuse. Now we have improved feeding devices, variable speeds, clinker grinders, air-cooled side wall tuyeres, and automatic regulators. All these show advantages when properly used, and most of them are being properly used today. The distance we can go with these refinements is limited only by the greater skill and intelligence that we are finding in our boiler rooms. It takes a certain amount of skill to manipulate any kind of stoker without refinements. Obviously it takes a much higher degree of intelligence to handle properly the refinements mentioned. The more nearly automatic stoking becomes, the greater the degree of intelligence required to manipulate the automatic features so as to make them responsive to variable conditions.

We already owe much to pulverized-fuel furnace construction. New ideas of combustion-chamber volumes and means for preserving refractories will open up new possibilities for stokers. The preheating of air may be a big factor in stoker operation. Higher permissible furnace temperatures due to the improved quality of refractories and methods of protecting against overheating, will make possible new economies along this line. Many of the large stokers of improved design have been in service only a short time, so that the figures on their operating cost over a long period are not available. In this connection it might be well to call attention to the fact that for purposes of comparison a 1923 pulzerized-fuel plant should not be compared with a 1915 stoker plant. The stoker still has a few degrees more to go before it reaches the maximum, and pulverized-fuel systems have yet to prove their overall commercial economy over a period of years.

The smaller plants are an increasing factor to be considered by stoker manufacturers. They are demanding higher types of combustion apparatus, and an increasing number of small plant operators are learning how to handle such apparatus. We have seen a great refinement in central-station equipment and operation. We are about due for a corresponding general improvement in combustion conditions in smaller plants. Coal is no longer wasted with indifference. There seems to be no end to improvements possible both in large and small plants, but we will always have to puzzle over the combination of those two great uncertainties—coal and personnel. This is what makes our art interesting both in the drawing office and in the boiler room.

Problems Met in Installing Pulverized Coal Systems

By J. W. Fuller
President, Fuller Engineering Co., Fullerton, Penn.

Our major difficulty is probably in persuading prospective customers that the design of pulverized-coal installations calls for as high a degree of specialization and experience as any other engineering problem. We are often approached by customers with a complete layout of their pulverized-coal needs and requested to furnish the equipment called for. A proper revision of the design and type of equipment will often reduce costs greatly, and is often absolutely essential if the installation is to operate satisfactorily as a whole. Even when the layout is left to us, certain equipment is often specified arbitrarily and against our advice, and the consequent unsatisfactory results are often ascribed to the use of pulverized coal instead of to the methods employed in using it.

Another point which necessarily must arise in making installations of pulverized-coal equipment is that the use of pulverized coal is not yet sufficiently widespread to have developed standard methods and design for all the possible applications. Furthermore, in such a new art comparison and study of previous work leads logically to new designs and developments which thorough engineering analysis will prove to be sound, but which are not represented in existing installations. These are often of such a nature as to require demonstration on a large scale and are not susceptible to laboratory or experimental justification. It, therefore, becomes necessary for the customer to meet the engineers halfway and regard the whole matter of pulverized-coal installations with an open mind, relying on the recommendations of those who have devoted intensive study to the matter. Otherwise, the progress of development is temporarily held up and the customer who shows too much conservatism is likely to find his plant rapidly becoming obsolete and less satisfactory than those built with a more progressive viewpoint.

It is often the case that those who are unacquainted with the use of pulverized fuel exaggerate its dangers, while on the other hand, those who have become converted to its use grow careless and permit conditions to develop which increase the possibility of danger. The same precautions should be observed in handling pulverized fuel that would be observed with any other easily inflammable fuel.

Further points in actual operation that sometimes develop misunderstanding between customers and manufacturers have to do with the manner of operation of equipment; for instance, the grinding elements of mills are often kept in use long after wear has made them distinctly unprofitable by reducing capacities. This condition is accelerated by running mills at considerably below capacity, when pulverizing actions that should be applied to material are in part transferred to the pulverizing elements.

Another factor that may lead to trouble is giving too little consideration to the thorough drying of coal. Improperly dried coal reduces the efficiency of the mills and the fluidity of the fuel, hampering its proper handling.

Still another difficulty that is sometimes encountered is insufficient supervision of operations as evidenced in some plants where less than the proper number of boilers will be allowed to carry all the load. As a result these boilers will operate at far above the rating for which the furnaces were designed, leading to operating difficulties.

Judging from the views expressed in the foregoing symposium, there appears to be a prevalent feeling, especially among operators and manufacturers of equipment, that innovations in power-plant design and practice may be going forward at too fast a pace.

Answering the Big Questions

Steam pressures are rising. Where will they stop? Is bleeder heating here to stay? If so what is the proper number of heaters and the best bleeding points? Does reheating offer more commercial gain than bleeding? Will future plants combine the two? Is the air preheater a freak invention or is it an appliance which must be seriously considered as a commercial proposition? These questions have for months been the focus of heated discussion wherever power engineers have gathered. The A.S.M.E. is doing its full share to find the answers. At the annual meeting the Power Session, on Dec. 6, will hear and discuss four masterly papers on the general subject of heat cycles and one on air preheating. These papers are necessarily quite long. To serve the busy engineer *Power* presents the following abstracts that cover the more important conclusions and some of the high lights of the methods used in reaching them.

Margins of Possible Improvement in Central-Station Steam Plants

By ERNEST L. ROBINSON*

THE purpose of the present article is to run over the whole field of steam-power-station possibilities in a general way and to point out the limiting efficiencies attainable and show the lines along which the greatest margins for possible improvement lie.

Fundamentally conceived, the steam plant is simply a heat engine for converting fuel into salable power. A heat engine receives heat from a hot source, does work, and rejects heat to a cold receiver. The process of combustion may be considered as the hot source and the condenser as the cold receiver. Heat is directly convertible into other forms of energy at a fixed theoretical rate known as the mechanical equivalent of heat or the heat equivalent of electric energy. If the ideal heat engine could convert all the heat into work at this rate, it would be necessary to reject the working substance devoid of all heat content; that is, at absolute zero. If, at any time, energy is reclaimed from the working substance, without other heat exchange, its availability to do work has been decreased a corresponding amount; that is, its absolute temperature has been changed.

For given temperature limits the maximum possible efficiency is represented by the actual temperature drop of the working substance divided by what the drop might be if all heat were abstracted; that is, the initial absolute temperature. This is the well-known Carnot-cycle efficiency and also the efficiency of any reversible engine.

Ideal Cycles Indicate Possible Lines of Advance

The idea of availability to do work is synonymous with thermodynamic efficiency, and this idea of loss of availability or thermodynamic efficiency in connection with the irreversible step is the important thing to note at this time.

In addition to the Carnot cycle, there is the regenerative process in which all heat that passes out of the working substance during cooling is transferred at its own temperature to an auxiliary contraflow substance, so that it may be restored at its own temperature during a similar return process.

Certain very elementary conclusions are possible at once from this review of simple thermodynamic principles. It is desirable to have as cold a receiver as possible, and since there are practical limits to this coldness, it is also desirable to have the source of heat at as high a temperature as possible in order to give the widest possible operating range. These are the things that must be kept in mind when deciding on the efficiency of the ideal process.

With steam as a working substance and modern turbine construction it has been found that vacuums corresponding to temperatures between 70 deg. and 80 deg. are the best that can be obtained with the cooling water available.

Difficult to Take Full Advantage of High Temperatures

At the other end of the process it happens to be far easier to produce high temperatures than to utilize their advantage, because, in the case of steam, the vaporization at a high temperature cannot be accomplished without confinement at an excessive pressure. Thus it is evident that the working temperature range is hedged around by various practical considerations which will need special consideration, and this will be given presently.

A glance at Fig. 1 shows that the higher the temperature—that is, the higher the ideal efficiency—the farther does the Rankine cycle fall short of it. This is especially true in the case of superheat, even though it improves the actual efficiency. Moreover, it follows that for any particular temperature the less the superheat the higher will be the efficiency. In fact, for a particular temperature the efficiency is far the best if the pressure is high enough for the steam to be saturated.

The question now arises as to what cycle can be used in order to cause the steam to turn over the heat in accordance with the best theoretical standards. Suppose steam is extracted from every stage of the turbine and that the number of stages is indefinitely increased. If at each stage just enough steam is extracted to heat the feed the infinitesimal temperature difference, each bit of steam so extracted has gone through a cycle reversible except for the infinitely small temperature drops during the feed heating, and these infinitesimal temperature drops occur in an unlimited number of small steps as in any regenerative process. The boiler temperature can thus be reached within an infinitely small amount. In other words, for saturated steam the extraction cycle as a whole is entirely reversible in the limit. It is not only

*General Electric Company, Schenectady, New York.

good for steam, but equally correct for saturated ammonia or saturated mercury. However, it does not apply to the case of a superheated vapor. This is an important fact to understand clearly.

This is about as far as abstract theory alone can go for the steam plant. The furnace and boiler have been imagined ideal by the use of regenerative air preheating with flue gases, and the turbine has been imagined ideal by using saturated steam and heating the feed to boiler temperature by extraction. Thus the total margins for improvement are shown very clearly in Fig. 1. It now becomes necessary to narrow the ideal still further by taking up the practical matters which determine the temperature limits and see what are the relative margins to gain among the various methods of increasing the efficiency. There are two principal questions: First, the temperature limits, and second, for established limits, how to approach as nearly as possible the ideal cycle.

Conservative practice places 750 deg. F. as the temperature limit at the present time. It has been made clear that, unless saturated steam is used, the efficiency of the process will fall far below the ideal. And with saturated steam these temperatures are above the critical, and the pressure above 3,000 lb. per sq.in. Both the excessive pressure and excessive moisture during expansion make it undesirable to use saturated steam at such temperatures.

There is a theoretical advantage in the use of high pressures, even though the temperature after super-

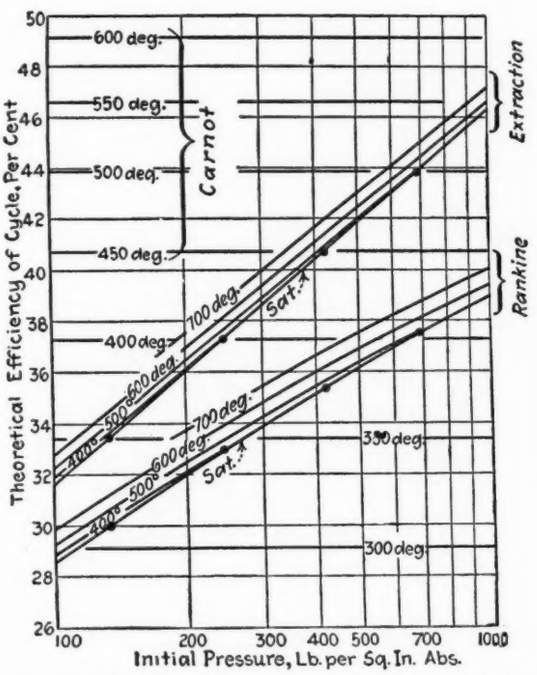


FIG. 1—THEORETICAL EFFICIENCIES OF STEAM CYCLES (Based on Goodenough, 1917. Curves are for various initial total temperatures, deg. F., as indicated. Back pressure, 1 in. Hg.)

heating is already at the limit fixed by the materials. The curves of Fig. 1 set forth the very material rise in theoretical efficiency with increase of pressure at various initial total temperatures, and it should be noted that the increase is still more rapid when steam extraction is employed.

The foregoing all points to the necessity of a substance whose vapor pressure will not be excessive at the temperature to which the materials of construction may be submitted. And this is the great advantage of the mercury turbine. Fig. 2 presents a temperature-entropy diagram for one pound of steam with a similar diagram for ten pounds of mercury drawn at the higher temperatures. In a particular machine the relative amounts of steam and mercury would be slightly different, depending on the temperature of the con-

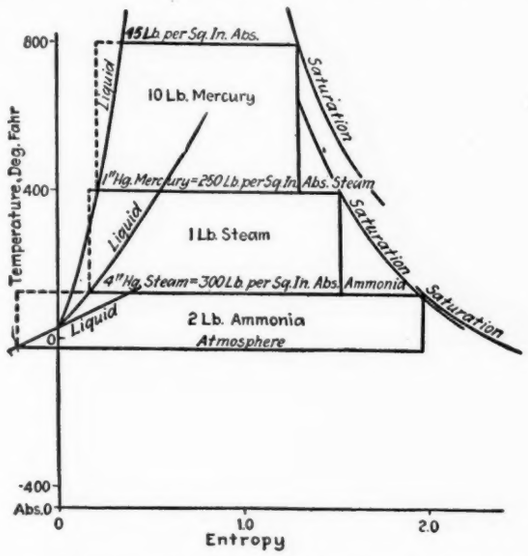

Temperature, Deg. Fahr
Entropy
15 Lb. per Sq. In. Abs.
10 Lb. Mercury
1" Hg. Mercury = 250 Lb. per Sq. In. Abs. Steam
1 Lb. Steam
4" Hg. Steam = 300 Lb. per Sq. In. Abs. Ammonia
2 Lb. Ammonia
Atmosphere
Liquid
Saturation

FIG. 2—TEMPERATURE-ENTROPY DIAGRAM FOR A COMBINATION OF MERCURY, STEAM AND AMMONIA

denser-boiler. The ten-to-one ratio is convenient for plotting. The low pressure of 45 lb. per sq.in. at 800 deg. F. is satisfactory, and the exhaust at one inch of mercury back pressure heats a steam boiler at 400 deg. and 250 lb. per sq.in. pressure, the steam from which may in turn be expanded to one inch of mercury back pressure. The entire working range of temperatures is from 800 deg. to 80 deg. F., and in each case wet vapors are used. In each case, also, extraction may, imaginably at least, be employed, although the mercury has so little liquid heat that its Rankine cycle is considerably nearer to ideal than is the case with steam. This process shows a theoretical increase of economy of 37 per cent, as compared with good modern turbine practice using steam at 350 lb. per sq.in. pressure and 700 deg. temperature, and a saving of 28.7 per cent as compared with the same turbine utilizing the extraction cycle to the limit.

The mercury turbine has thus given a practicable way to reach the upper temperature limit as fixed by the strength of materials. The aim in that direction is now being directed at the materials of construction, and this is entirely correct.

At the other end of the process, the condenser, the temperature limit is fixed by natural conditions. Cooling water sufficient to maintain a vacuum at 80 deg. is about as good as can usually be expected. However, it is the intention of this paper to look somewhat beyond immediate possibilities in a variety of directions. Fig. 2 also includes the liquid and saturation lines for ammonia, and if a turbine were supposed to be equipped with an ammonia condenser-boiler, then another turbine, an ammonia turbine, might as easily continue the process as the steam turbine continued the mercury process. If such a steam plant were located in the polar

regions in winter so that the atmosphere could condense the ammonia at —25 deg. F., it would be possible to expand the ammonia to atmospheric pressure. Now if the feed is heated by extraction as in the case of the steam and mercury, the efficiency would be such as to effect a saving of 45 per cent over the case of a steam turbine working with the Rankine cycle at 350 lb. per sq.in. pressure and 700 deg. temperature. It may also be noted here that sulphur dioxide could be used with less severe pressures than ammonia.

Having thus discussed what the theoretical efficiency is and how various practical limitations determine what is ideal in any particular case, the next matter to consider is the utilitarian question of the value of the various improvements already instituted. The practical advantage of extraction depends on the number of heaters. Very roughly it may be said that, in comparison with no feed heating, the use of one heater will realize between a third and a half of the full theoretical gain, and also, very roughly, that each additional heater will realize an improvement about half as large as the last preceding heater added to the system.

The advantage of superheat is almost entirely a matter of practical application due to the limitation of a high initial pressure. The desired temperature cannot be attained with wet steam without incurring too high an initial pressure. Hence the pressure is pushed as high as possible and superheat is then used to give a slight theoretical gain plus an additional practical gain due to the fact that more turbine disks rotate in dry steam. Still further the greater heat turnover per pound of steam results in an even greater reduction of water rate, which is advantageous in permitting a larger capacity rating of the machine.

The desirability of resuperheating is due largely to the same reasons that apply in the case of initial superheat, but the possibilities of practical application to any particular advantage are limited to about one or two steps of resuperheating.

Moisture Extraction Promises Substantial Gains

Drying may be accomplished by the same process as resuperheating, namely, by the addition of heat; but if the addition of heat is only sufficient to dry the steam without superheating it, the gain will be slight. On the other hand, if the drying is done by moisture abstraction, the gain is very appreciable if the moisture is used for feed heating.

In all that has been said so far, there has appeared no place for an economizer. Indeed, as far as the theory goes, it appears to be anomalous, but in all these cases where a substantial practice has grown up there is always a good common-sense reason sufficient to justify it at the time. Whether the practice should continue or not is always an appropriate question. The discharge of hot flue gas was a material waste. To pump cold water into a hot boiler was bad. And the transfer of heat from hot gas to water was a practical process well known, since it was taking place in every boiler; hence the economizer.

To secure an exchange of heat between large quantities of air with reasonable temperature differences is not so easy. The design of such apparatus is progressing at the present time, however, and installations of this nature have been made. It is certainly a process theoretically of such distinct value as to warrant serious attempts to accomplish its practical use. On the other hand, the success of this process will not in itself displace the economizer. The economizer works at temperatures roughly betfween 300 and 600 deg., whereas grate manufacturers prefer the air to enter the furnace at a temperature less than 300 deg. or certainly not much more. This is another real limitation on the realization of the ideal arrangement. The inability to utilize this flow of fluid for returning low-grade heat to the furnace means definitely a corresponding amount of waste. Here is a good reason for pulverized fuel, if it will permit the use of very hot air.

There are several methods of connecting up these channels for the return of low-grade heat to the system. In examining them it should be kept in mind that the idea is always to have the heat transfer occur with the least possible temperature difference. That is, the process should be as nearly truly regenerative as possible.

The use of extracted steam for air preheating is another scheme, but the air circulation can carry back only about half as much heat per degree rise as the water circulation. Moreover, the limitation of grate temperature has been noted. It is thus evident that, even if all the air preheating should be done by extracted steam, it would still be desirable to extract more for feed heating.

New Cycle Would Place Economizers in Parallel with Heaters

Still another arrangement occurs to the author. The economizer must receive reasonably cold water in order to work efficiently, whereas the extraction process is not pushed to its limit unless it heats the water to boiler temperature. Present arrangements send the feed water from the heaters to the economizer, thus dividing the available temperature range between the two heating devices. A more efficient way than to divide the temperature rise would be to divide the circulation into two roughly equal parts (supposing pulverized fuel and no limitation on the air-preheating temperature). One branch of the system would be sent to the economizer as it comes from the hotwell and should enable the cooling of the flue gases to a materially lower temperature than with feed water already preheated. The other branch of the system should be arranged to receive extracted steam, included appropriate amounts from the high-pressure stages, since these temperatures no longer detract from the action of the economizer. Similar amounts of extracted steam would be used for preheating the air. Such a process in perfect adjustment would approach the ideal.

If steam auxiliaries are used for other reasons, the exhaust heat from these may be used for feed-water heating. The heat thereby returned to the system is not lost in itself, but for a given quantity of heat recirculated the auxiliaries can turn less into useful work than the main units. In other words, inefficient auxiliaries should not be placed in a station in order to provide feed heat which may be obtained from the more efficient main units. The same applies to other sources of low-grade heat about the station which may be used for feed-heating purposes.

It is a fortunate circumstance that improvements in efficiency usually result in a greater power output from a given amount of working substance and thus tend to increase the rated capacity of a machine. For instance, from 130 lb. per sq.in. absolute and saturated steam with the Rankine cycle to 750 lb. per sq.in. and 750 deg. temperature with the extraction cycle, the capacity is just doubled, while the economy is improved one-third.

High Pressure, Reheating, and Regenerating*

By C. F. HIRSHFELD† and F. O. ELLENWOOD‡

In this paper the authors discuss the relative thermal and investment costs involved in a modern turbo-generator station, as determined by a consideration of steam pressures from 200 to 1,200 lb. per sq.in., steam temperatures of 700 and 800 deg., and six different cycles of operation in which reheating and regenerating are involved in various degrees.

THIS paper is a study of the relative thermal and investment costs involved in a modern turbo-generator central station, as determined by a consideration of steam pressures from 200 to 1,200 lb. per sq.in., steam temperatures of 700 and 800 deg. F. and six different cycles in which reheating and regenerating are involved in various degrees.

The work naturally divides itself into two parts, the first of which deals with the information that may be gained from a study of the ideal cycles, the second with the probable fuel economies and operating characteristics that may be expected from real plants operating on the several cycles and at various pressures. The second portion of the paper also includes the relative investment costs which have been worked out in so far as they are affected by the various cycles and steam pressures.

The different cycles have been designated respectively by the first six letters of the alphabet. The names chosen are intended to be characteristic of the most unusual parts of the cycle. Temperature-entropy charts for these theoretical cycles are shown in Figs. 1 to 6.

The Cycle with Isothermal Superheating (C) consists of the processes shown in Fig. 3. This name is used because the cycle involves an isothermal expansion of superheated steam as indicated by the line *cd*. It is not claimed that this process is likely to be approached even approximately in any real turbine. The study of this cycle, however, does offer one great advantage, in that it shows a maximum that might be approached by using an infinitely large number of constant-pressure reheating devices.

In *the Regenerative Cycle* (D), Fig. 4, the curve *de* is drawn for the entire weight of steam considered in

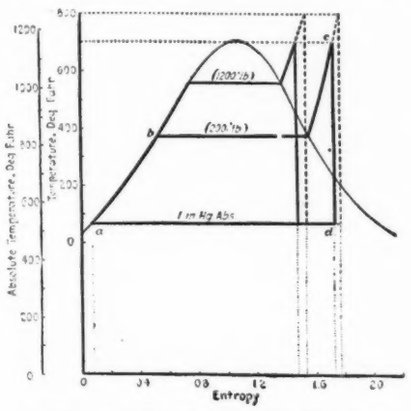


FIG. 1—DIAGRAM OF CYCLE A (RANKINE)

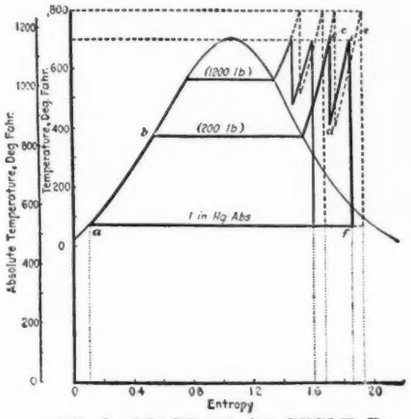


FIG. 2—DIAGRAM OF CYCLE B (REHEATING)

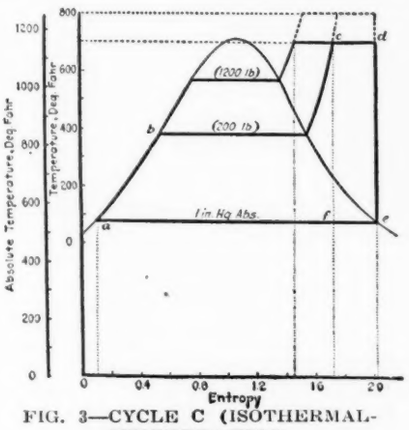


FIG. 3—CYCLE C (ISOTHERMAL-SUPERHEATING)

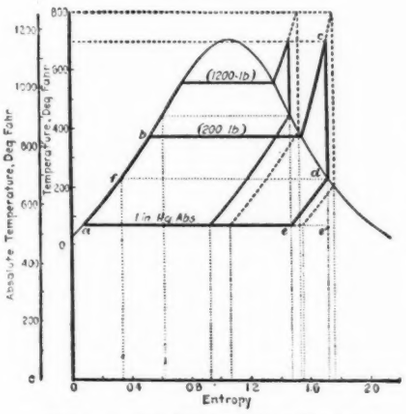


FIG. 4—DIAGRAM OF CYCLE D (REGENERATIVE)

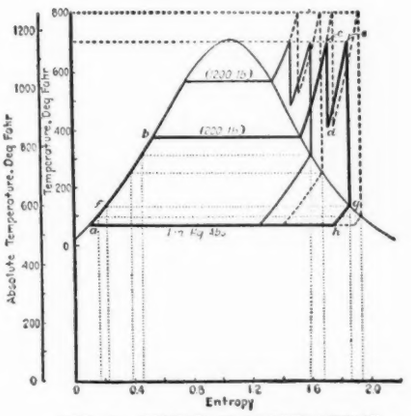


FIG. 5—CYCLE E (REHEATING REGENERATING)

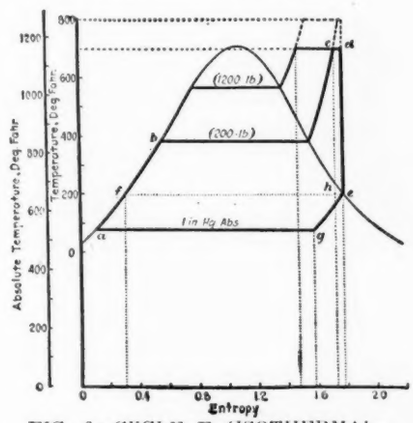


FIG. 6—CYCLE F (ISOTHERMAL-REGENERATIVE)

*Abstract of paper presented at the annual meeting of the A.S.M.E., New York City, Dec. 3 to 6, 1923.

†Chief of Research Department, Detroit Edison Company.

‡Professor of Heat-Power Engineering, Cornell University.

the cycle and does not represent the state of only that portion of the steam continuing through the turbine. By drawing the diagram to represent all of the steam considered, the area *abcde* represents the energy available from this amount of steam and the equations for the cycle efficiency may be developed readily. In case superheated steam should be bled, the process cannot be shown in the superheated field by drawing a line parallel to the liquid line. It is particularly instructive to observe from Fig. 4 how the temperature of the feed water rises in this cycle as we go to high pressures.

The Reheating-Regenerative Cycle (E) is outlined in Fig. 5. It is called "reheating-regenerative" for the reason that the steam is reheated as is the case of cycle B, and then the regenerative principle is also applied as discussed for cycle D. Therefore the area *abcdegh* represents the available energy in B.t.u. per pound of throttle steam.

The Isothermal-Regenerative Cycle (F) is made up of the processes shown in Fig. 6. This cycle can hardly be called an important one except in so far as it indicates the limiting possibilities of cycle E with an infinitely large number of reheaters, so that the isothermal expansion in the superheated region is approached as shown by the curve *cd*.

In Fig. 7 are given the efficiencies of the six cycles arranged so that they may be compared for a throttle temperature of 700 deg. F. and various throttle pressures from 200 to 1,200 lb. per sq.in. Clearly, cycle D is the one that deserves first place, especially for the

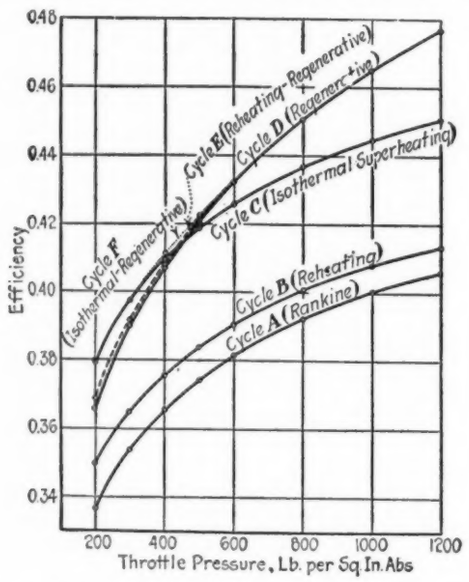


FIG. 7—COMPARATIVE MAXIMUM EFFICIENCIES OF CYCLES A, B, C, D, E, AND F

Throttle temperature of 700 deg. F. and exhaust pressure of 1 in. Hg abs.

higher pressures, as far as efficiencies on the ideal basis are concerned.

For any cycle herein there is a marked increase in efficiency and in energy available per unit volume of exhaust steam, due to increasing the throttle pressure, throughout the range considered. This increase in efficiency with the pressure is less marked in the simple Rankine cycle than in the ones with more complicated apparatus.

The efficiencies to be expected from turbo-generators of 30,000 kw. capacity when operating on the cycles under consideration with different pressures and temperatures have been calculated as well as possible, and the results are shown in Fig. 8.

From the curves of Fig. 9 it would appear that the 1,200-lb. plant will cost only about 14 per cent more than the 200-lb. one to operate on the same cycle.

The coal consumption of plants operating under different conditions as to steam pressure and cycle, is

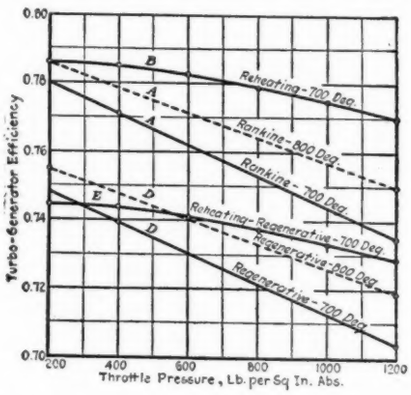


FIG. 8—PROBABLE TURBO-GENERATOR EFFICIENCIES REFERRED TO THE FOUR IDEAL CYCLES, A, B, D, AND E

For 30,000-kw. units and exhaust pressure of 1 in. Hg abs.

of great interest to engineers at the present time. For the pressures and cycles considered in this study the curves in Fig. 10 represent unbiased estimates which have been made in a manner that is believed to be reasonable. Time did not permit preparing diagrams in which loads less than 100 per cent would be considered. The general relation of the curves would, however, remain the same for all cases except those in which the stand-by losses are excessive.

If it be assumed possible to extract the water formed during expansion of the steam, as, for example, by drainage to the heaters, the efficiency of the turbine operating on the regenerative cycle will be better than shown in Fig. 8 and the fuel consumption of the plant less than that shown in Fig. 10.

For pressures of about 600 lb. per sq.in. it appears, from Fig. 10, to make but little difference what cycle other than the Rankine is chosen from the consideration of fuel alone.

The curves of Fig. 11 show the relative costs of the energy delivered at the switchboard of the various types of plants under consideration in this study. The curves have been drawn so that the index figures all refer to the Rankine cycle with a pressure of 200 lb. per sq.in. as the standard of comparison. The throttle temperature is assumed to be 700 deg. in all cases.

From the curves of Fig. 11 it appears that with coal at $5 per ton and a pressure of about 600 lb. it is immaterial what cycle is used other than the Rankine. It is also clear from these curves that with five-dollar coal, pressures higher than 600 lb. are not so attractive as sometimes believed. As the capacity factor is decreased to values less than 100 per cent, the high pressures are still less attractive. With coal costing $8 a ton the best pressure for base-load conditions would appear to be near 1,000 lb. per square inch.

Experience with high-pressure equipment and with auxiliary apparatus which the use of high-pressure steam appears to involve is as yet exceedingly limited. No one is today really in position to say positively that

the high-pressure equipment now coming into use will operate with that smoothness and certainty required to justify its use for the sake of the increased thermal efficiency obtainable. Under such conditions it would seem to be best to use first the simplest types and to progress toward the more complicated if further experience indicates such progress to be desirable. From such a point of view the simple Rankine cycle would be best if it gave sufficient promise of increased efficiency with increased pressure. Unfortunately, it does not, and it is therefore necessary to consider a more complicated cycle of operation. Our present knowledge indicates two choices, that involving regenerative heating only and that involving reheating with or without regeneration. Of the two the regenerative cycle is unquestionably the simpler, and in fact it is hardly more complicated than the Rankine now in use.

Considering all the factors that enter into the problem, it seems to the authors that the high-pressure regenerative plant is the most promising for commercial development. It is certainly true that the performance here estimated for such a plant can be further improved by using a turbine designed to separate and remove water formed during expansion. Some of the designs now available provide for such drainage at the bleeder points to a certain extent, but it seems probable that the best results cannot be attained unless effective moisture separators are actually built into the turbine structure.

It is essential to note that economizers become of less value with the regenerative cycle as the initial steam pressure is increased. This suggests immediately that air heaters be used with such plant to conserve waste heat not available for use in economizers fed with high-temperature water. It is obvious that it will be necessary to heat the air in such devices to temperatures from 100 to 200 deg. above normal air temperature if full conservation of waste heat is to be made.

The studies outlined in this paper, together with others with which the authors are familiar, indicate plainly that the improvement in economic results to be expected from the use of higher steam pressures in plants designed to take full advantage of the possibilities latent in the use of such pressures are sufficiently great to make it appear quite probable that the more progressive engineers and executives will construct plants of this character in ever-increasing numbers.

It is to be expected that higher pressures will be adopted first and more frequently in connection with plants of the base-load type and in regions in which fuel costs are high.

The authors feel that steam pressures of the order discussed in this paper should no longer be regarded as of theoretical interest only. Most of the major problems involved in the design and arrangement of equipment for utilizing such pressures have been solved or are nearing what appear to be satisfactory solutions, and it is believed that careful engineers who are thoroughly familiar with the peculiar features involved in this sort of work can safely install equipment for even the highest pressures here considered when the circumstances and conditions of use justify such installations.

It is exceedingly difficult to state categorically any definite upper limit of temperature, but it is felt that a figure between 700 and 750 deg. represents the safest upper limit of steam temperature at the present time.

The authors believe that this study indicates that even with the present type of turbine the regenerative cycle is the best one to use in large stations, as it ranks very high from the viewpoint of fuel consumption, operating characteristics, and first cost throughout the entire range of pressures, but particularly so above 600 lb. per sq.in. With a turbine that the authors believe can be developed so as to remove the moisture to a considerable degree, this cycle will give still better economy, and it seems altogether reasonable to expect that this equipment in the turbine room, combined with that now developed to yield high boiler-room efficiency, will give station economy that will pay handsomely for the increased investment.

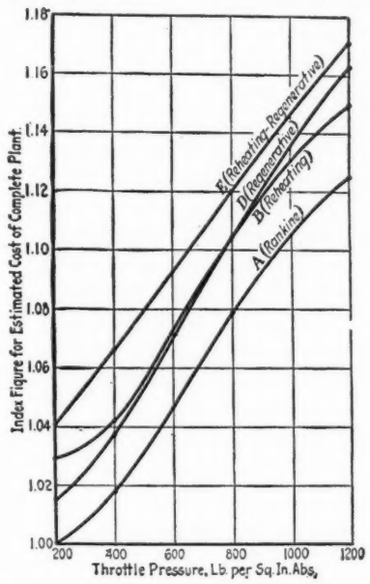


FIG. 9—ESTIMATED RELATIVE COSTS OF COMPLETE CENTRAL STATIONS, INCLUDING BUILDINGS AND LAND

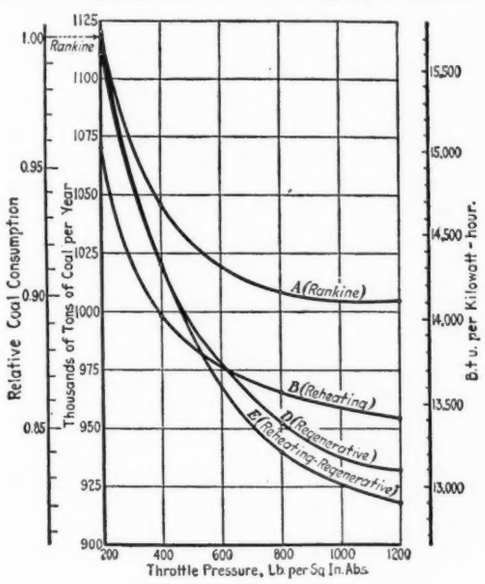


FIG. 10—RELATIVE COAL CONSUMPTION OF 200,000-KW. PLANTS OPERATING ON VARIOUS CYCLES AND STEAM PRESSURES

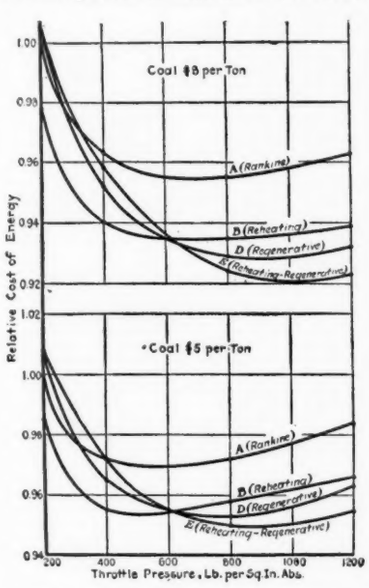


FIG. 11—EFFECT OF STEAM PRESSURE AND CYCLE ON COST OF ENERGY AT SWITCHBOARD OF 200,000-KW. PLANT

Economy Characteristics of Stage Feed-water Heating by Extraction*

Practical Computation and Maximum Realization of Extraction Gains for Power Plants of Present Trend in Design

By E. H. BROWN† and M. K. DREWRY†

WHEN one realizes that comptometers are displacing slide rules for power-plant calculations, that nearly every heat unit is being accounted for, and that resultant power units are no less immune in the ever-growing crusade for maximum economy, error of 0.5 per cent in over-all plant economy may easily be occasioned by a single incorrect assumption or omission due to lack of understanding of the extraction characteristics of steam turbines. To point out the influence of each possible variable in the computations

COMPUTATION OF FEEDWATER HEATING CYCLE

Steam Conditions:- 350 lb. gage; 250 deg. fahr.; 29 in. vacuum
Equipment in Cycle:- Two heaters

			Fractional Load				High-Pressure Heater, Approx. Fractional Loads			Low-Pressure Heater, Approx. Fractional Loads		
	Non-Extracting Operation		1/2	3/4	M.E.	Full	1/2	3/4	M.E.	1/2	3/4	M.E.
1	Output, Kw.	(given)	10,000	15,000	18,680	20,000	..	..	..	..	..	..
2	Steam Rate, lb. per kw-hr.	(given)	10.18	9.65	9.53	9.57	..	..	..	..	..	..
3	Total Steam, lb. per hr. (No. 1 × No. 2)		101,800	144,800	178,000	191,400	..	..	..	..	..	..
4	Generator Efficiency	(given)	0.948	0.960	0.964	0.966	..	..	..	..	..	..
5	Brake Horsepower Output [No. 1 ÷ (No. 4 × 0.746)]		14,120	20,920	26,000	27,750	..	..	..	..	..	..
6	Total Heat at Throttle, B.t.u.per lb.(From steam table)		1356.5	1356.5	1356.5	1356.5	..	..	..	..	..	..
7	Work Done, B.t.u. per lb. [(No. 5 × 2545 ÷ No. 3) + % for friction]		353	368	372	369	..	..	..	..	..	..
8	Total Heat at Exhaust, B.t.u. per lb. (No.6 minus No.7)		1003.5	988.5	984.5	987.5	..	..	..	..	..	..
9	Heat of Liquid at Hotwell, B.t.u. per lb. (Steam table)		47	47	47	47	..	..	..	..	..	..
10	Heat Supplied by Boiler, B.t.u.per lb.(No.6 minus No.9)		1309.5	1309.5	1309.5	1309.5	..	..	..	..	..	..
11	Heat Consumption, B.t.u. per kw-hr. (No. 2 × No. 10)		13,331	12,637	12,482	12,533	..	..	..	..	..	..
12	Inlet Pressure, lb.abs. (M.E. and full-load values = throttle pr. abs. - 5% and 7% resp.; 1/2 and 3/4 load values are proportional to No. 3,M.E.load)		200	284	350	340	..	..	..	..	..	..
	Extracting Operation											
13	Pressure at Nozzle, lb. abs. (M.E.load value given; others proportional to No. 3)						10.05	14.3	17.4	2.61	4.0	4.9
14	Pressure at Heater, lb. abs. (No. 13 minus 5% pipe drop and 2% extraction drop at h.-p. nozzles; 5% extraction drop at l.-p. nozzles)						9.35	13.3	16.2	2.53	3.6	4.4
15	Saturation temperature at Heater Pressure, deg. fahr. (From steam table)						190	207	217	135	149	157
16	Final Feedwater Temperature [No. 15 minus terminal difference (7 deg.)]						183	200	210	128	142	150
17	Heat of Liquid of No. 16,						151	169	178	96	110	118
18	Heat Supplied by Boiler, B.t.u. per lb. [No. 6 minus No. 17 (for h.-p. heater only)]						1205.5	1188.5	1178.5	..	..	..
19	Total Heat at Nozzle, B.t.u. per lb. (From Mollier expansion lines)						1137	1137	1141	1076	1076	1079
20	Total Heat at Exhaust, B.t.u. per lb. (No. 8)						1003.5	988.5	984.5	1003.5	988.5	984.5
21	B.t.u. per lb. Work Lost in Extracted Steam (No.19 minus No. 20)						133.5	148.5	156.5	72.5	87.5	94.5
22	Kw-hr. Work Lost per 1000 lb. per hr. of Steam Extracted $\left(\frac{\text{No. 21} \times \text{No. 4} \times 1000}{3416}\right)$						37.0	41.7	44.3	20.1	24.6	26.7
23	Total Heat of Steam at Each Heater, B.t.u. per lb. (No. 19 minus radiation losses)						1137	1137	1141	1079	1076	1076
24	Heat of Liquid of Steam at Each Heater, B.t.u. per lb. [No. 17 + term. diff. (7°); for						158	175	185	47	47	47
25	Heat Available for Heating Feedwater, B.t.u. per lb. (No. 23 — No. 24) 1-p. htr., No. 9]						979	962	956	1032	1029	1029
26	Final Temperature of Feedwater, deg. fahr. (No. 16)						183	200	210	128	142	150
27	Initial Temperature of Feedwater, deg. fahr. (No. 26 of lower-pressure heater)						128	142	150	79	79	79
28	Temperature Rise of Feedwater, deg. fahr. (No. 26 minus No. 27)						55	58	60	49	63	71
29	Quantity of Feedwater, lb. per hr. [No. 3 (except for 1.-p. heater = No. 3 minus sum of No. 33 for all higher-pressure heaters.]						101,800	144,800	178,000	96,120	136,140	166,910
30	Heat Transferred to Feedwater, million B.t.u. per hr. (No. 28 × No. 29 ÷ 10^6)						5.6	8.4	10.68	4.72	8.57	11.84
31	Heat Flashed into Heater by Drained Condensate, million B.t.u. per hr. (No. 28 × sum of No. 33 of all higher-pressure heaters)						..	..	..	0.31	0.50	0.66
32	Net Heat Supplied by Extracted Steam, million B.t.u. per hr. (No. 30 minus No. 31)						5.6	8.4	10.68	4.41	8.07	11.18
33	Weight of Steam Extracted, lb. per hr. [No. 32 × 10^6) ÷ No. 25]						5,720	8,720	11,170	4,280	7,860	10,870
34	Kw. Work Lost in Extracted Steam, kw-hr. (No. 33 ÷ 1000 × No. 22)						211	364	495	86	193	290
35	Total Kw. Decrease in Output, kw-hr. (Sum of No. 34 for all heaters)						297	557	785	..	..	..
36	Kw. Output Extracting (No. 1 minus No. 35)						9,703	14,443	17,894	..	..	..
37	Per Cent Decrease in Output when Extracting (No. 35 ÷ No. 1)						2.96	3.7	4.18	..	..	..
38	Steam Rate, lb. per kw-hr. (For exact fractional loads of units proportioned for extracting, No. 3 ÷ No. 36)						10.490	10.025	9.948	..	..	..
39	Steam Rate, lb. per kw-hr. (For non-proportioned units, from curve of No. 38 vs. No. 36 at exact fractional loads)						10.437	9.996	9.948	..	..	..
40	Heat Consumption, B.t.u. per kw-hr. (No.18 × No. 38 if extraction unit, No. 18 × No. 39 if not proportioned)						12,583	11,880	11,724	..	..	..
41	Weight Extracted, Fractional Loads, Each Heater, lb. per hr. (No. 33 + % given in No.37)						5,850	8,980	11,550	4,420	8,160	11,350
42	Weight Extracted, Fractional Loads, All Heaters, lb. per hr. (Sum of No. 41)						10,270	17,130	22,900	..	..	..
43	Total Steam, lb. per hr. (No. 3 plus % given in No. 37)						104,700	150,000	185,000	..	..	..

FIG. 1—SAMPLE CALCULATION OF A TWO-HEATER CYCLE

In making complete calculations, steam-jet air pumps, deaerators, evaporators, and steam-driven auxiliaries are given columns just as are the theaters

(Sample forms for computing the feedwater heating cycle as above may be procured upon application to the Secretary of the A. S. M. E., 29 W. 39th St., New York.)

then he appreciates that present power-plant requirements demand the nearly perfect agreement between theory and practice which, unfortunately, has been so long in attainment.

Feed-water heating by extraction from the main unit, becoming increasingly important for both thermodynamic and practical reasons with rising steam pressures, complicates the computation of heat balance. An and finally to illustrate a comprehensive though not tedious method for their allowance, is the first purpose of this paper.

Where heaters can be most efficiently placed thermodynamically, how their number and the temperature to which they work influence turbine-room economy, to what extent auxiliary equipment limits the gains acquired by extraction heating, how the type of turbine employed affects the same benefits, and how other factors affect turbine-room economy, were ascertained by accurate computations using the method mentioned,

*Abstract of paper presented at the annual meeting of the A.S.M.E., New York City, Dec. 3 to 6, 1923.

†Steam-Turbine Department, Allis-Chalmers Manufacturing Co.

taking into account all conditions as they actually exist in representative installations, and are submitted in the second portion of the discussion. Turbine-room variables and approximations alone have been attacked, and it is hoped that boiler-room computations may be similarly approached so that the average power-plant designer or operator, aided only by manufacturers' guarantees and an elementary knowledge of thermodynamics, may accurately compute a representative heat balance for any installation.

Much has been published of the benefits of feed-water heating by stage extraction, but comparatively little has been written of how those benefits are computed. Since installations in different power stations are rarely identical, the necessity of calculating cycles for each plant is imperative if accurate results are to be expected. A comprehensive method, utilizing no gross approximations, which may apply at one plant and not at another, but which, nevertheless, must be simple, conducive of mathematical accuracy, and adaptable to all types of cycles, is needed.

A method developed in the offices of the company with which the authors are associated is thought to possess these qualifications. It has not been made empirical for the sake of brevity; it attacks all details of the problem and aims to attain simplicity and accuracy only by convenient and logical arrangement of the calculations.

Only three fundamental processes are necessary in computing feed-water heating economies. They are: Determination of the heating value of the extracted steam; computation of the amount to extract; determination of the effect of extraction upon output and, consequently, upon economy.

Finding the heating value of the extracted steam and its effect in decreasing output (if no additional throttle steam is supplied) involves the use of an all-important tool in this work—the turbine expansion line as drawn upon a standard Mollier chart. From this simple line

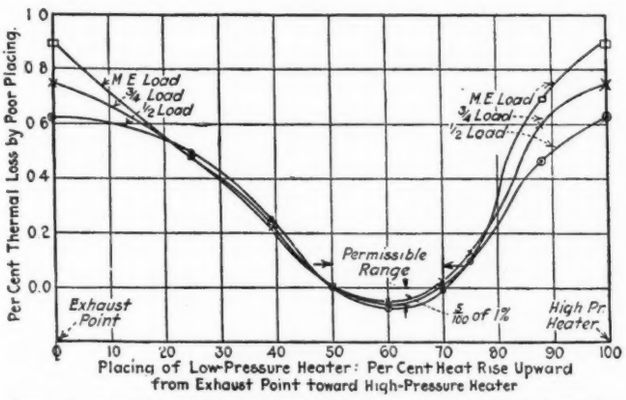


FIG. 2—BEST THERMODYNAMIC PLACING OF HEATERS

Calculations of complete cycles show that for best economy with two-heater cycles the lower heater should do approximately 60 per cent of the feed-water heating. For multi-heater systems the lower-pressure heaters should carry slightly more of the heat load than the upper ones, though accurate placing is not thermally important.

can be read directly the temperature, quality, total heat, and work done at any pressure in the machine and at any fractional load with an accuracy comparable to test accuracy. Once the expansion line is obtained, feed-heating calculations are a matter of simple arithmetic. Fig. 1 shows a sample calculation of a two bleeder cycle[1].

For this study a representative cycle of two heaters, heating to 210 deg. at most economical load, was initially chosen. The low-pressure heater was varied in position from 25 per cent to 87 per cent of the heat-drop interval between the high-pressure heater and the exhaust, and the resulting economies figured.

Fig. 2 shows that the best economy is obtained when operating with the low-pressure heater at a point 60 per cent of the heat-drop interval upward from the exhaust, or in this case at a pressure of about 4 lb. per sq.in. absolute. Under these conditions slightly more heat is transferred in the low-pressure heater, though

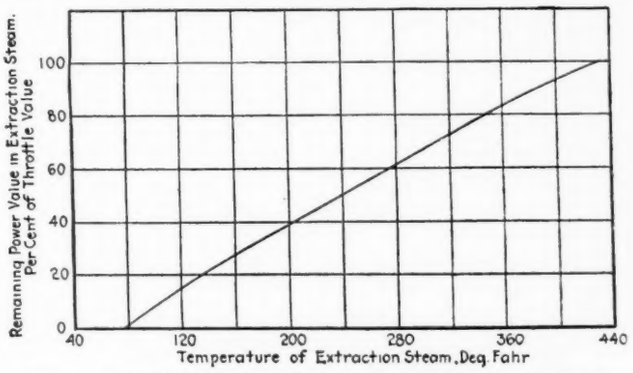


FIG. 3—COMMERCIAL VALUE OF STEAM AT VARIOUS PARTS OF A TURBINE

Curve showing why extraction at low temperatures affords inexpensive steam and why the plan of heating feed water by bearing oil and generator cooling air has a competing method because of the cheapness of heating by extraction.

considerably more power is lost in steam extracted from the high-pressure nozzle. Accurate placing of heaters is not of great importance.

A representative two-heater cycle, heating to 210 deg. F. at most economical load and containing a steam-jet air pump, showed increases of 1.1 per cent, 0.84 per cent, and 0.71 per cent in heat consumption at ½, ¾, and most economical loads, respectively, above the same cycle computed without an air pump. True, average steam consumption of the air pump (0.8 per cent of full-load throttle total steam) heated the feed-water as much as 15 deg. F., but this being done at an extremely low temperature level by high-temperature-level steam resulted in decreasing the benefits of extraction heating from, for example, 5.5 per cent to 4.5 per cent. The fallacy of the time-worn expression crediting steam-jet air pump, injector and other steam auxiliary equipment in power stations with 100 per cent efficiency is thus strikingly indicated. If mechanically practical and fully as reliable as the steam-jet air pump, economical motor-driven vacuum pumps, with air pumps in reserve as "augmenters" or as auxiliaries when starting, would be desirable equipment, though continuity of service is of great importance in this consideration.

Since extraction gains are caused by obtaining work from the extracted steam before it passes to the heater, the amount of work done in the machine down to a given pressure is a criterion of extraction efficiency. Machines with inherently inefficient high-pressure stages are at a disadvantage, therefore, in producing economy in extraction feed-heating systems.

Due to the low temperature level of the heated generator air and bearing oil, their utilization for purely thermal considerations is questionable so long as feed-water is heated by stage extraction. As shown by Fig. 3, extraction steam taken from a 120-deg. nozzle (the average temperature of generator air and bearing oil) has given up 85 per cent of its power value in doing work before being extracted, and any heating it may do

[1]For the details of this method see the original paper.

is at a cost of only 15 per cent of its value at the throttle. Four per cent mechanical and electrical losses, originally produced with a thermal efficiency of not more than 25 per cent, represent 1 per cent of the total heat, or enough to heat the feed water about 12 deg. The same temperature rise could be obtained by extracting 1.2 per cent of throttle total steam from the 120-deg. nozzle, causing a maximum heat-consumption increase of in the neighborhood of 0.2 per cent. Whether the more costly apparatus required for heat transmission from oil and air warrants substitution for the simpler heating by extraction steam in heaters already provided, is questionable, unless of course the additional appa-

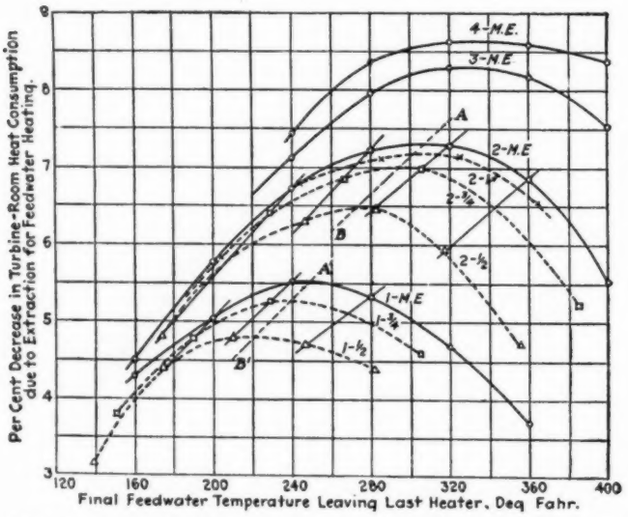


FIG. 4—PERCENTAGE OF HEAT SAVING EFFECTED BY EXTRACTION HEATING TO VARIOUS TEMPERATURES WITH DIFFERENT NUMBERS OF HEATERS, AS COMPARED WITH NON-FEED-HEATING OPERATION

Results of accurate computations of complete cycles, considering all extraction variables (with exception of leaving loss) in a typical installation, showing net and comparative turbine-room gains for a representative large-unit high-pressure machine, though applicable to others with small error. Curve 1-M.E. is for a one-heater cycle, most economical load; Curve 2-¾ is for a two-heater cycle at three-quarter load, etc.

ratus serves the dual purpose of cooling and heating as in closed generator cooling-air systems.

Allowing for terminal difference, extraction and pipe pressure drops, flashing, and using all refinements in cycle computations, representative systems heating to different maximum temperatures with one, two, three and four heaters were accurately computed. In Fig. 4 the results are compared with heat consumption for non-extraction operation, though the curves afford intercomparison as well.

In agreement with previous published investigations, the curves show maximum benefits to occur at 245, 300, 320, and 330 deg. when heating with one-, two,- three-, and four-heater cycles, respectively. They also represent comparative economies in percentage of heat consumption at any final temperature and for any practical number of heaters. Fractional-load curves for the one- and two-heater cycles show the comparative economies at full and reduced loads, indicating maximum economy for all loads obtainable, not with constant feed-water temperature, but with changes just as they occur at extraction nozzles with variable loads, represented by the straight lines adjoining the calculated points in both systems. It will be appreciated that besides cutting the peaks of each set of curves, the straight lines *AB* and *A'B'* also indicate the natural drop in temperature at the specific nozzle heating feed water to those most efficient temperatures. Unless boiler-room practice rigidly requires constant feed-water temperatures at economizer inlets, the inherent simplicity of extraction stage heating can be maintained in the future.

Increase in the number of heaters, besides improving economy at any given final temperature and increasing the most economical temperature, broadens the range over which the system can operate without causing great decrease in economy. Three- and four-heater-cycle curves are appreciably flatter than those of fewer heater cycles.

The use of combustion-air economizers, adoption of the unit system, improvement in the reliability of auxiliaries, and the growing demand for simplicity in power-plant construction all point toward the steady adoption of the stage-extraction method of heating feed water.

That air preheaters can effectively lessen the economical rating of feed-water economizers, thus allowing greater benefits of extraction feed-water heating to accrue by heating to higher temperatures in the turbine room, seems probable. Mechanically and thermally successful air heaters have been tried and tested with creditable results, decreasing chimney temperatures to exceedingly low amounts while carrying part of the economizer heat loads. Increasing the turbine-room feed-water temperature to 300 deg. from the present practice of 210 deg. is therefore not improbable. The change would decrease economizer corrosion, increase boiler rating and allow a gain in over-all plant economy of a magnitude determinable by use of Fig. 4. The increase in feed-water temperature mentioned above would additionally improve turbine-room heat consumption 1.25 per cent if a two-heater system were in use, and 1.95 per cent for a three-heater system.

In smaller installations the plan of motorizing the auxiliaries, coupled with the inherent self-regulation of feed-water temperature in extraction systems, may render steam-turbine rooms more or less automatic in control. Auxiliaries can be permanently tied electrically to the main or auxiliary generator, gaining in speed with it when starting and being automatically shut down upon stopping. Feed-water heating by other means, because of the attention necessary for approximate constant-temperature maintenance and of the attention to auxiliary turbines, does not adapt itself to automatic control. Where economy considerations do not demand extraction heating, ease of operation may be a factor contributing to its installation.

Larger installations with positive sources of current for auxiliary operation need maintain no inefficient steam-driven auxiliaries, with perhaps the exception of a few stand-by boiler-feed pumps, and thus may realize the full benefits of stage extraction. With the increasing interlinkage of power stations steadier line conditions are assured, promising greater reliability of motorized auxiliaries in cases where auxiliary generators are not employed. By its nature, feed-water heating by stage extraction appears to adapt itself well to present power-plant practice, and continued adoption is anticipated.

Accuracy in extraction calculations can hardly be expected with the use of simple equations representing the involved internal characteristics of modern turbines. These characteristics must be understood, and for their expression the Mollier expansion line seems best suited. In calculating resulting heat consumption, allowance for all conditions in the cycle is needed for accurate results.

Reheating in Central Stations*

By W. J. WOHLENBERG†

In this paper the author discusses the influence of amounts of energy added in reheating, number of reheating stages, and points in expansion at which reheating should begin. A comparison is made of reheating, regenerative and combination cycles combining both reheating and bleeding stages, and it is shown that, because of the influence on the internal machine efficiency thereby, reheating properly applied may lead to higher efficiencies than bleeding. It is furthermore shown that the combination cycles give promise of realization in practice of appreciably higher efficiencies than would be the case for the other cycles investigated. The analysis also indicates that for a limiting steam temperature of 750 deg. F., the maximum efficiency is attained at initial pressures varying between 600 and 900 lb., the exact optimun depending upon cycle, fuel and steam generator used; and that if pressures are increased beyond these points, there will result an actual reduction in over-all efficiency.

IN AMERICA some reheating has been carried on, but little concerning it has been published. This paper is accordingly first occupied with an attempt to discover the proper place of reheating in the central station on an ideal basis. Secondly, modifications of ideal conditions leading to expected practical performance are introduced.

The single-stage reheating cycle is illustrated on the temperature-entropy diagram in Fig. 1. In this diagram T is absolute temperature, and ϕ is entropy. Starting with condensate at A, it is heated up to the saturation temperature at B, then evaporated along BC, superheated at constant pressure along CD, expanded adiabatically along DE, then reheated along EG, and expanded to condenser pressure along GI, then condensed along IA. The reheat area is represented by $FEGH$ and the gain of work by $EGIJ$.

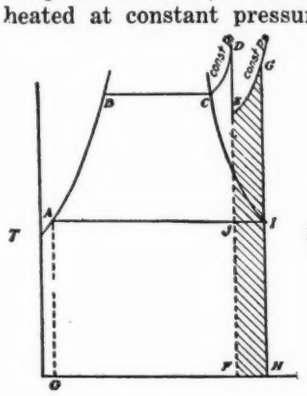


FIG. 1—ONE-STAGE REHEATING CYCLE

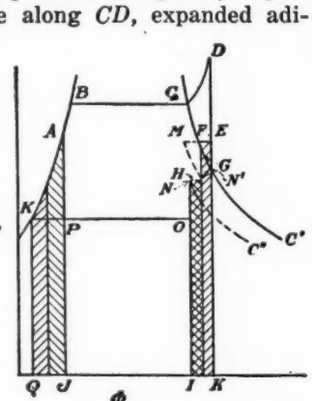


FIG. 2—TWO-STAGE BLEEDING CYCLE

In this analysis upper steam temperatures of 750 deg. F., will be considered as the limit of good design and 1,000 deg. F. as a possible coming future standard.

Fig. 2 shows a two-stage bleeding cycle on the temperature-entropy diagram. The saturation line is represented by $CFMGHC''$, rather than by CC'. The sharp breaks to the left are caused by the depletion in total-steam quantities at bleeding points. For every pound of steam entering the turbine, only a fraction of a pound, due to bleeding, is exhausted, but the quality variations in the expansion following bleeding are just as if no bleeding had taken place.

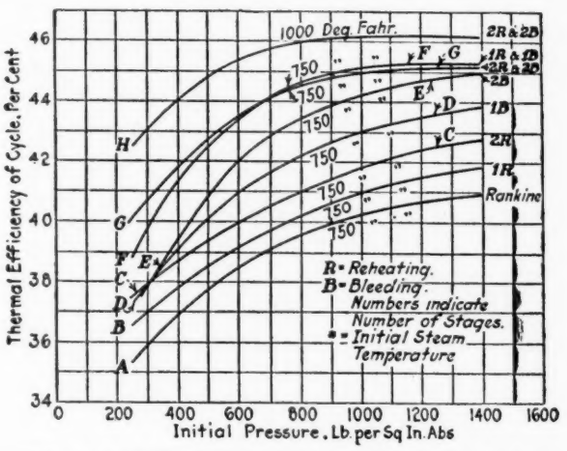


FIG. 3—EFFICIENCIES OF VARIOUS REHEATING AND OTHER CYCLES

Steam conditions, *A* to *F*, inclusive: Initial temperature 750 deg. F.; back pressure 1 in. Hg.
Steam conditions for curve *H*: Initial temperature, 1,000 deg. F.; back pressure, 1 in. Hg.
Bleeding points: 240 deg. F. or 25 lb. in one-stage bleeding cycles. 280 and 180 deg. F. or 50 lb. and 7.5 lb. in two-stage cycles.

That bleeding theoretically produces much greater gain than reheating may be seen from Fig. 3, where A shows the Rankine cycle, B the single-reheating cycle, C the double-reheating cycle, D the single-bleeding cycle and so on as indicated by the abbreviations at the right of the curves. Curves F, G and H are for combinations of reheating and bleeding. For example, curve H shows the theoretical efficiency for 1,000 deg. maximum temperature with two-stage reheating and two-stage bleeding.

From a study of diagrams like those for Figs. 1 and 2, prepared for a variety of combinations, the most favorable reheating and bleeding conditions may be chosen. They are as follows:

One-Stage Reheating—140 B.t.u. to occur in the cycle after a 140-B.t.u. drop in the expansion line.

Two-Stage Reheating—120 B.t.u. per stage occurring alternately with expansion after successive 120-B.t.u drops in expansion line.

One-Stage Bleeding—Condensate raised to 240 deg. temperature. Pressure = 25 lb. abs.

Two-Stage Bleeding—Condensate raised first to 180 deg. and then to 280 deg. Bleeding Pressures, 7.5 lb. and 49 lb. abs.

These conditions apply for an initial steam temperature of 750 deg. When this is increased to 1,000 deg., the energy added in reheating is increased to 250 and 200 B.t.u. per stage, respectively, for the one- and two-stage cycles.

*Abstract of paper presented at the annual meeting of the A.S.M.E., New York City, Dec. 3 to 6, 1923.

†Assistant professor of mechanical engineering, Yale University.

A fulfillment of these fundamental conditions may lead to a change in order of the reheating-bleeding processes as the pressure range is followed through. This *R-B* order will, however, be left to appear as it happens to be fixed by the foregoing more important considerations. The best efficiencies for various pressures and cycles are shown in Fig. 3.

From Fig. 3 it may be concluded that combination cycles are considerably more efficient than the other

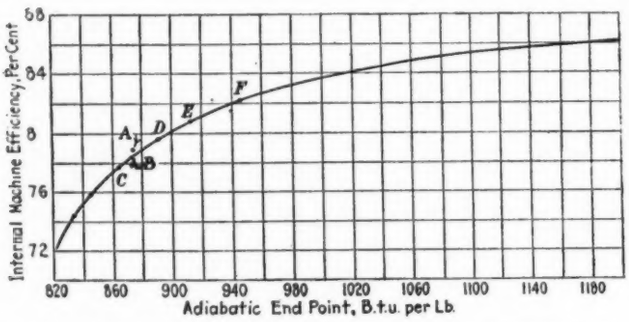


FIG. 4—RELATION OF INTERNAL MACHINE EFFICIENCY TO ADIABATIC END POINT

A—60,000-kw. 3-cyl. Westinghouse compound.
B—30,000-kw. single cylinder G. E.
C, D, E, F—30,000-kw. Westinghouse compound. Back-pressure, 1 in. Hg.

cycles investigated, that the ideal efficiency increases rapidly as the pressure increases, but beyond 1,000 lb. little is to be gained, and that an increase in initial temperature materially increases the efficiency.

The next phase of the problem naturally has to do with relating of ideal and actual performances. This involves the influence of the various processes on the internal machine efficiencies of the prime movers.

The thermal efficiency of the actual internal work will be equal to the product

$$E_c \times E_i$$

in which E_c is the thermal efficiency of the cycle and E_i the internal machine efficiency. The product times E_m,

TABLE I—END-POINT HEAT CONTENTS AND INTERNAL MACHINE EFFICIENCIES FOR VARIOUS CYCLES AND CONDITIONS

(Heat contents in B.t.u.; efficiencies in per cent.)

Initial Pressure, Lb.	Rankine and Bleeding Cycles, 750 Deg. End Pt.	Rankine and Bleeding Cycles, 750 Deg. Mach. Effy.	One-stage Reheating, 750 Deg. End Pt.	One-stage Reheating, 750 Deg. Mach. Effy.	Two-Stage Reheating, 750 Deg. End Pt.	Two-Stage Reheating, 750 Deg. Mach. Effy.	Two-Stage Reheating, 1,000 Deg. End Pt.	Two-Stage Reheating, 1,000 Deg. Mach. Effy.
300	912	80.8	983	83.4	1,035	84.5	1,145	85.8
600	865	77.8	940	82.0	989	83.5	1,110	85.3
1,200	818	71.8	890	79.6	943	82.2	1,102	85.2

TABLE II—HEATER PRESSURES FOR VARIOUS BOILER PRESSURES

(Pressures in lb. per sq.in.)

Initial Pressure	Reheater Pressures — One Stage	Reheater Pressures — Two Stages — 1st Stage	Reheater Pressures — Two Stages — 2d Stage
300	88	105	46
600	170	210	70
1,200	290	380	120

the mechanical efficiency, will result in the over-all efficiency of work at the shaft based on the heat energy absorbed by the working medium. The efficiency product $E_i \times E_m$ involves the following losses: (*a*) Nozzle and blade frictional losses, (*b*) Leakage and disk friction, (*c*) Gland, bearing, and governor friction, (*d*) Radiation.

The first two of these determine E_i and the fourth may be included with the third as part of the loss involved in E_m.

A detailed determination of E_i throughout the turbine involves factors known only to the turbine designer, but its mean value may be computed from test results. These with proper corrections may be applied to the conditions of the problem.

Fig. 4 shows that there is a fairly definite relation between the internal efficiency E_i of a machine and the adiabatic end point of the expansion, the latter being found by tracing out the ideal cycle on the Mollier chart. Table I shows the adiabatic end point for various conditions. A study of Table I in connection with Fig. 4 shows that unless reheating is used the machine efficiency is relatively low at high pressures.

Fig. 5 shows the thermal efficiency at the shaft for an actual turbine. It will be noted that with the actual cycle reheating gives better efficiency than bleeding, whereas with the theoretical cycle bleeding was superior

TABLE III—STEAM-GENERATOR EFFICIENCIES FOR VARIOUS CYCLES AND PRESSURES

Steam temperature, 750 deg. One-third of total surface in economizer; one-pass gas flow; averate rate of heat absorption, 5,000 B.t.u. per sq.ft. per hour

	Steam pressure, lb. per sq.in.	300	600	1,200
One-stage bleeding	Escaping-gas temperature, deg. F.	430	500	580
	Combined efficiency, per cent	82.8	80.8	78.4
Two-stage bleeding	Escaping gas temperature, deg. F.	470	540	620
	Combined efficiency, per cent	81.8	79.8	77.8
Rankine	Efficiency, per cent (90 deg. F. feed-water)	85.2	83.2	80.8

to reheating. The highest efficiency of all is obtained by the two-stage combination cycle; that is, two reheating stages and two bleeding stages. At 750 deg. initial temperature the most efficient pressure is in most cases under 1,000 lb. The fact that steam generators naturally fall off in efficiency with increasing pressures will tend to throw the high-efficiency points still farther down the pressure scale.

Reheating surface will normally be included within the boiler setting to withdraw heat from the products of combustion. Mean steam temperatures within them will be somewhat higher than boiler-surface temperatures for 300-lb. and 600-lb. pressures, but for 1,200-lb. stations they will actually be somewhat lower. The

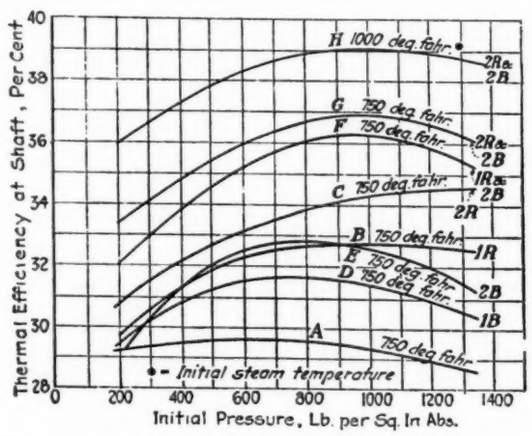


FIG. 5—THERMAL EFFICIENCIES AT SHAFT BASED ON HEAT ABSORBED

pressures existing within the reheaters will be considerably below those existing in the boilers, as shown in Table II. It appears, therefore, that for a given heat absorption reheater surface advantageously placed may not be more expensive than boiler surface. This would be particularly true if the reheating surface should be exposed directly to furnace radiation, as under these conditions the rate of heat absorption would be very high. Such an arrangement also has obvious advantages when considering maintenance of furnace walls and should lead to higher steam-generator efficiencies. The reheater maintenance may, however, be

high and there are some operating disadvantages which may make the arrangement undesirable particularly at light loads when the reheating would be excessive. The reheater in the gas-convection path appears to have, in the present state of the art, more desirable operating characteristics. When the heat absorption in reheaters is large, it may, however, be found advantageous to absorb part of the energy directly from furnace radiation.

For high pressures boiler-surface temperatures will be increased with a corresponding rise in the escaping-gas temperature. Economizer surface will, owing to high feed-water temperatures, absorb less heat in two-stage than in one-stage bleeding stations.

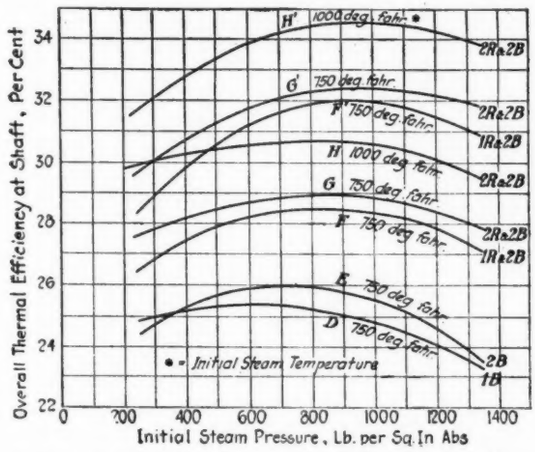


FIG. 6—OVER-ALL THERMAL EFFICIENCIES OF A GIVEN STEAM-GENERATING PLANT FOR VARIOUS COMBINATION AND BLEEDING CYCLES

(Auxiliaries, electric generator and pipe-line radiation losses not included.)
Curves *D*, *E*, *F*, *G*, and *H* for a stoker-fired plant.
Curves *F'*, *G'*, and *H'* for a powdered-coal maximum-efficiency plant in which steam-generator efficiency is 88 per cent.

The expected efficiencies for a stoker-fired plant with a steam generator proportioned as shown in Table III and absorbing heat at the average rate of 5,000 B.t.u. per sq.ft. per hour are stated in Table III.

Curves *D*, *E*, *F*, *G* and *H*, Fig. 6, represent the over-all efficiencies by combining the foregoing steam-generator efficiencies with those from Fig. 5. It is apparent from these curves that no gain may be expected by increasing pressures beyond 850 lb.

When high load factor and cost of fuel make feasible the use of steam generators of exceedingly high efficiencies, the following modifications may be made: Decreased average rate of heat absorption, increased ratio of economizer to boiler surface, installation of air preheaters, burning coal in powdered form. Under these conditions average steam-generator efficiencies of 86 to 90 per cent may be realized even for the high-pressure two-stage-bleeding stations.

For a steam-generator efficiency of 88 per cent a new set of efficiency and economy curves represented by *F'*, *G'* and *H'* in Fig. 6 are arrived at. Reference to them indicates that for 750-deg. steam the maximum-efficiency point occurs at 1,000-lb. pressure. The efficiency has a value of 32.3 per cent and the economy is 10,300 B.t.u. per kw.-hr. at the turbine shaft. Generator losses, power for auxiliaries, and pipe-line radiation have not been included. If 10 per cent is charged to these three items the net results are as follows:

Net over-all efficiency = 29.1 per cent.

Net economy = 11,500 B.t.u. per kw.-hr. at the bus.

We may conclude that the station with a net over-all economy of 12,000 B.t.u. is in sight. Its characteristics and principal dimensions may be about as follows:

Initial steam pressure, 900 to 950 lb. per sq.in.
Initial steam temperature, 750 deg. F.
Back pressure, 1 in. Hg.
Steam Cycle: Combination $2R + 2B$.
Reheating, 120 B.t.u. per stage per lb.
Bleeding, 49 lb. and 7.5 lb.
Condensate, 280 deg. F. and 180 deg. F.
Steam Generator:
Surface equally distributed between boiler and economizer.
Average rate of heat absorption, 3,000 B.t.u. per sq.ft. per hr.
Air-preheater surface per s.ft. of surface in boiler and economizer, 0.2 sq.ft.

Boiler, superheater, and economizer surface per kw. $= \frac{12{,}000}{3{,}000} \times 0.88 = 3.52$ sq.ft.

Boiler, superheater, and economizer surface corrected for reheating per kw. $= \frac{1{,}345 - 248}{1{,}345 - 248 + 240} \times 3.52 = 2.89$ sq.ft.

Reheating surface per kw. = (?) depends on position.
Energy absorbed in reheater per kw.-hr. = 1,900 B.t.u. = 18 per cent of total.
Air-preheater surface per kw. = $0.2 \times 3.52 = 0.70$ sq.ft.
Temperature of gases escaping from boiler, 620 deg.
Temperature of gases escaping from economizer, 350 deg.
Temperature of gases escaping from air preheater, 260 deg.
Draft loss in boiler and economizer, 4 to 5 in. water.
Draft loss in air preheater, 4 to 5 in. water.
Fuel: Powdered coal burned with 20 per cent excess air.

The following conclusions may be drawn from what has been presented:

a. With increasing pressures and a limited steam temperature reheating is becoming essential for highest efficiencies.

b. The introduction of reheating stages does not operate to make bleeding stages less beneficial, and in the future stations both bleeding and reheating stages will probably be incorporated in the steam cycle.

c. Under present limiting conditions as to steam temperature there is little to be gained by using more than two reheating stages.

d. Reheating should be accomplished as early in the expansion period as possible.

e. For variable-load operation the reheating coils should preferably be placed in the gas-convection path screened from direct furnace radiation and the load on the steam generators maintained proportional to that of the prime movers.

f. For stoker-fired plants using the combination cycle material gains in economy should result by increasing pressures up to between 700 and 800 lb., but beyond this point no apparent gains exist.

g. In powdered-fuel plants using the combination cycle material gains in economy may be expected by increasing pressures up to 900 lb., but beyond this point no apparent gains exist.

h. To increase pressures materially above points noted in (*b*) and (*g*) will apparently result in an actual reduction of economy for the conditions stated.

i. For properly designed stoker-fired plants operating on the combination cycle at optimum conditions, economies of 13,000 B.t.u. are apparently in sight.

j. For properly designed powdered-fuel plants operating under optimum conditions, economies of 12,000 B.t.u. and better appear possible.

k. Future improvements in turbine design may slightly influence optimum pressures. Such improvements will, however, probably lead to a proportional shift in the internal-machine efficiency curve, resulting merely in a higher efficiency at nearly the same optimum pressure.

l. More accurate information on the properties of high-pressure steam may lead to a readjustment of optimum pressures for the conditions stated. It is thought, however, that only small readjustments will result from this cause.

Boiler-Test Results with Preheated Air*

Excellent Results Obtained at Colfax on Boiler Equipped with Air Heater—Boiler Efficiency Increased Six or Seven per Cent—First Cost and Upkeep Low—Flue Temperature at Damper Lower Than Without Heater

By C. W. E. CLARKE†

THIS paper gives the results of tests recently made at the Colfax Station, Duquesne Light Company, on a boiler equipped with a flue-gas air heater. The tests, extending from July 14 to Aug. 4, were supervised by Dwight P. Robinson & Co., Inc.

The general arrangement of the preheaters, ducts, dampers and fan is shown in Fig. 1. The air is taken into the preheater from the boiler room directly over the boiler, carried down the duct by the fan and discharged into the stoker wind-box by means of two ducts extending on either side of the boiler. The duct work is insulated to prevent loss of heat.

The preheater itself is shown in Fig. 2, and was constructed by the Combustion Engineering Corporation, following in general the designs of the Underfeed Stoker Company, Ltd., of London, England, excepting in the one important respect that the heating elements

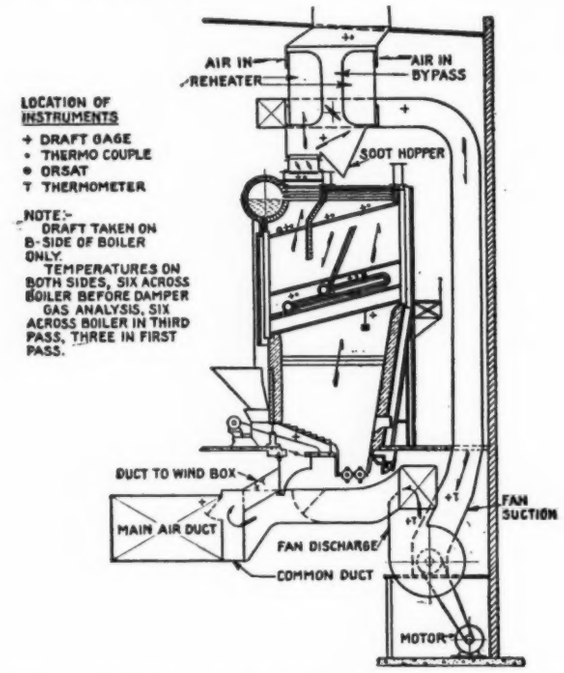

AIR IN REHEATER
AIR IN BYPASS
LOCATION OF INSTRUMENTS
+ DRAFT GAGE
• THERMO COUPLE
• ORSAT
T THERMOMETER
NOTE:- DRAFT TAKEN ON B-SIDE OF BOILER ONLY. TEMPERATURES ON BOTH SIDES, SIX ACROSS BOILER BEFORE DAMPER GAS ANALYSIS, SIX ACROSS BOILER IN THIRD PASS, THREE IN FIRST PASS.
SOOT HOPPER
DUCT TO WIND BOX
MAIN AIR DUCT
FAN DISCHARGE
COMMON DUCT
FAN SUCTION
MOTOR

FIG. 1—GENERAL ARRANGEMENT OF BOILER AND PREHEATER SYSTEM

are placed back to back and separated by a bypass space fitted with a damper. It will be noticed that the arrangement of two banks of elements back to back, as shown, makes available the maximum surface in a given vertical dimension.

The preheater is riveted and calked, but it was found impossible to make it tight. There is therefore a considerable infiltration of air into the flue gas, resulting in an exaggerated reduction in temperature after the preheating and a reduction in actual preheater performance. A new design, using welded construction throughout, has been developed and will be used for the installa-

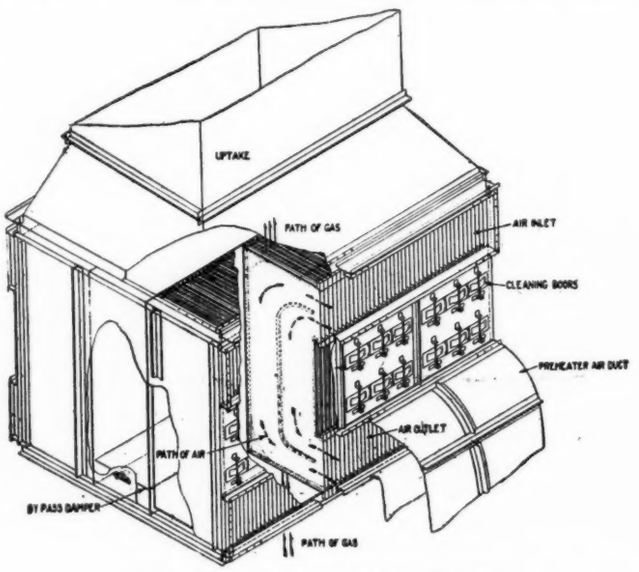


FIG. 2—DETAIL OF PREHEATER

tion now under way. An increase in preheater efficiency should be gained thereby.

The accompanying table gives data on the boiler used in the test.

DATA ON TEST BOILER (NO. 9)

Babcock & Wilcox cross-drum, water-tube type boiler.
Installation, 1922.
Heating surface, 22,914 sq.ft.
Steam working pressure, 275 lb. per sq.in. gage.
Normal rating (100 per cent), 79,053 lb. of water from and at 212 deg. F.
20 tubes high, 51 tubes wide, 4 in. diameter, 20 ft. long.
60-in. diameter drum, 34 ft. 1 in. long.
Setting 30 ft. 1 in. wide inside of walls.
Babcock & Wilcox superheater containing 2,999 sq.ft. heating surface, located in first pass of boiler.
Furnace volume, 7,500 cu.ft.
Westinghouse Underfeed stoker, 17-retort, 20 tuyere, extra-long stoker with side-wall tuyeres.
Clinker grinder, double-roll, separate drive on each side of boiler.
Grate, 29 ft. 10¼ in. wide by 13 ft. 6 in. effective length.
Projected area of grate, 218.31 sq.ft.
Grinder pit section, 163.89 sq.ft.
Preheating surface, 11,200 sq.ft.

Curves shown in Fig. 3 indicate comparative boiler performance with and without preheated air. The increase in efficiency due to preheated air varies from 5½ per cent at 114 per cent rating to 7 per cent at 200 per cent rating, the general effect being a tendency to flatten out the curve in the case of the preheated air tests. This is due to the increase in heat transmission of the preheater with the increase in temperature and volume of flue gas and air through the preheater and also to the marked decrease in the percentage of combustible in the ash.

The exit-gas temperatures were lower with preheated air, the amount of reduction varying from 15 deg. at the lowest rating to 10 deg. at 200 per cent of rating.

*Abstract of paper presented at the annual meeting of the A.S.M.E., New York City, Dec. 3 to 6, 1923.

†Power Engineer, Dwight P. Robinson & Co.

The curves indicate an average increase of CO_2 for the results with preheated air varying from 0.7 per cent at the low rating to 1.4 per cent at 200 per cent rating. This in itself causes a substantial saving.

The increase in fuel bed and front wall temperature for the test with preheated air over that without, shown on curves in Fig. 4, is considerably greater than the increase of the wind-box air temperature on account of the reduction in excess air. The remaining curves in Fig. 4 are interesting in that they indicate the relative gas temperatures through the boiler.

Preheated air operation decreased the draft loss through the boiler about 20 per cent for the low rating and 30 per cent for 200 per cent rating. The records also showed that grinding out of the ashpit was less frequently required in the case of tests using preheated air.

Fig. 5 shows the approximate distribution of difference in efficiencies with and without preheated air plotted from cumulative heat-balance curves with the difference in the various losses superimposed on the efficiency curves. These curves show clearly the proportion of the total efficiency gain which is due to better combustion conditions. The heat recovered from the ashpit loss is represented by the difference between curves *EF* and *CD*, but the variation in radiation and unaccounted-for loss brings the net gain to the efficiencies represented by curve *AB*.

The outstanding advantages of the flue-gas air preheater are evidenced by the installation at Colfax in addition to the gain in boiler efficiencies as presented in the test results are simplicity, low cost of installation, low maintenance, small operating charges.

In the matter of maintenance it may be argued that the preheater installation at Colfax has not been operated long enough to establish definitely reliable data. However, it is evident that the only item questionable is the preheater-element construction. There has been, up to the present time, absolutely no indication of deterioration in this connection, and in addition the reduced amount of equipment required for the preheater installation in comparison with an economizer installation naturally reduces maintenance charges.

The only operating cost chargeable to the preheater installation is the power required for moving the air through the preheater and duct system. In this particular installation this amounts to about 5 kw.-hr. per ton of coal fired, or the equivalent of less than 0.4 per cent of the coal used in the boiler.

In addition to this the more even furnace conditions, resulting in a less troublesome and smoother operation, constitute an asset that is quite real even though it may be difficult to capitalize its value.

The preheater equipment was placed in operation on May 7 and was in service until June 13, when the boiler was shut down for overhauling prior to the tests. Some readjustments were made in the spacing of elements which had been forced out of line on account of uneven expansion stresses. The boiler and preheater were placed on the line again July 10 and, with the exception of the period for the tests run without preheater, were in continuous operation supplying preheated air until Oct. 19, when trouble with the preheater fan necessitated taking air again from the regular forced-draft fan duct. Careful inspection of the preheater revealed no indication of soot or other deposits, so that it was unnecessary to make use of any soot-blowing equipment, although the installation of such equipment was considered at the time the equipment was put in service. The vertical position of the elements and the weaving of the plates due to temperature and pressure variations, together with the scouring action of the gases, are evidently responsible for this condition.

These tests do not indicate in any sense the limit in temperature that can be successfully used for combustion air. There are no indications whatever of any undesirable effects on the stoker parts or of general combustion conditions which are not favorable to the higher air temperatures used. It is quite probable that still better results could be gained with somewhat higher temperature than that used.

The reduction in boiler draft loss in a measure offsets the draft loss through the preheater, so that the height of stack to offset the drop in flue-gas temperature is not so great as would ordinarily be expected.

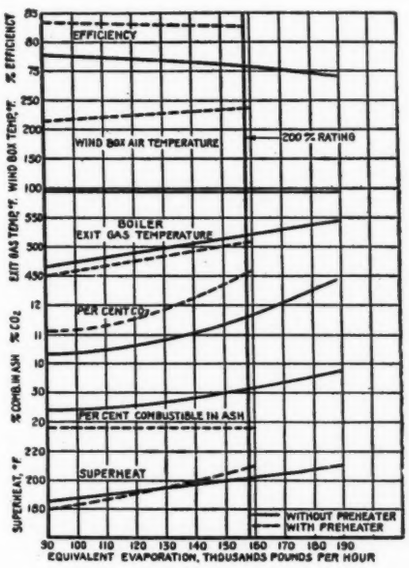


FIG. 3—COMPARATIVE PERFORMANCE WITH AND WITHOUT PREHEATING THE AIR

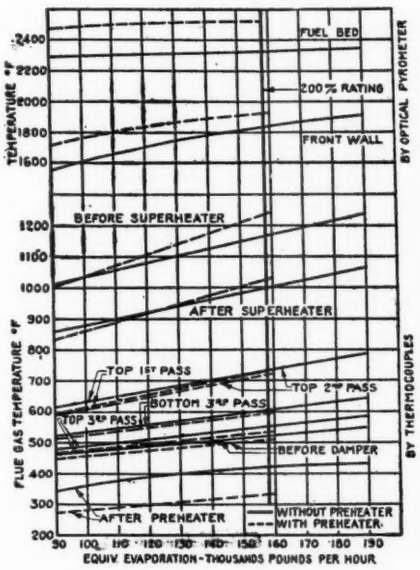


FIG. 4—FURNACE AND GAS TEMPERATURES WITH AND WITHOUT PREHEATING THE AIR

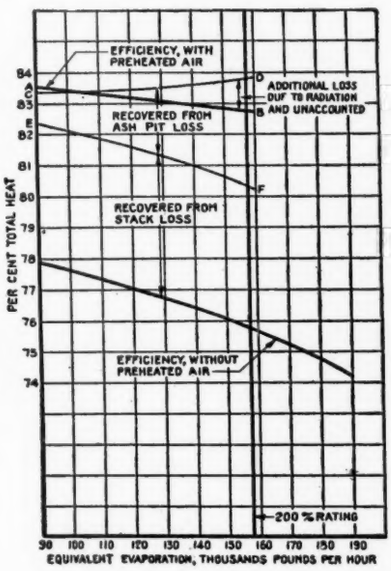

EFFICIENCY, WITH PREHEATED AIR
ADDITIONAL LOSS DUE TO RADIATION AND UNACCOUNTED
RECOVERED FROM ASH PIT LOSS
RECOVERED FROM STACK LOSS
EFFICIENCY, WITHOUT PREHEATED AIR
200% RATING
EQUIVALENT EVAPORATION, THOUSANDS POUNDS PER HOUR

FIG. 5—DISTRIBUTION OF DIFFERENCE IN EFFICIENCIES DUE TO PREHEATING

Second Power Show Opens

Approximately 260 Booths—Exhibits Reflect Advance Power-Plant Practice During Year—Many Working Models

THOSE who attended the Power Show at the Grand Central Palace, New York, last year were practically unanimous in proclaiming it a signal success. Although it was the initial appearance, nearly one hundred firms exhibited and the attendance numbered forty-seven thousand. This year approximately two hundred and sixty manufacturers are exhibiting power-plant equipment, and there is every reason to expect an attendance far in excess of last year owing to the date having been advanced to coincide with the annual meetings of the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers. Moreover, a number of out-of-town N. A. S. E. associations are planning to attend as well as the locals of that and similar associations.

Many Working Models Shown

Working models never fail to attract the attention of the visitor at a show of this kind and usually are one of the best means of conveying the idea of the workings of a piece of apparatus. The number of working models and machines in actual operation this year outnumber those seen last year. Among these may be mentioned:

A one-eighth size model of a Bigelow-Hornsby water-tube boiler in operation shows the circulation of water and the passage of the gases across the heating surfaces.

The Gifford-Wood Co. has working models of a standard coal pocket.

The R. H. Beaumont Co. shows a working model of a skip hoist with the Simplex Loader, suspended steel bunker, coal weigh larry and cable drag scraper.

Of special interest to the heating and ventilating engineer will be a miniature model of a Webster Modulation system of steam heating by an electrically heated boiler. Another working model of the same company is that of the return apparatus of a low-pressure heating system featuring the operation of the return and the vent traps.

The Keasbey & Mattison Co. is showing an operating steam coil having various thicknesses and kinds of insulation with thermometer readings and charts, so that the spectator can note the degree of efficiency of these various forms of insulation.

A four-foot model to exact scale of a large unit for water softening and filtering forms part of the exhibit of the Permutit Co. In this miniature even the small pipes and strainers in the interior of the water softening tank have been reproduced.

A one-half size model of the Burnhorn "Smaltower" shows the cooling tower in operation. Thermometers are provided so that the temperatures can be obtained and the cooling results demonstrated. This model was exhibited at the show last year, but is also one of the features of this year's exhibit.

Another exhibit of last year which attracted considerable attention and which is again showing is a complete operating exhibit of the Yarway-Lea V-Notch meter in which the motor-driven centrifugal pump circulates water at the rate of 50,000 lb. per hour.

Demonstrations of a unit of the Bethlehem-Dahl oil burning system show how it is possible to atomize fully at low pressures, and in connection with this exhibit a new compact arrangement of heaters and pumps is featured.

Still another operating model is a one-tenth size steel conveyor belt built by the Sandvik Steel Co.

Operating engineers will be particularly interested in a test kit to determine the oxygen concentration in water by the Winkler method, which the Elliot Co. is planning to have at its booth in charge of an operator who will demonstrate its operation.

A demonstration of the effect of various pipe fittings on fluid flow is made by the Bailey Meter Co. with the idea of showing the suitability or unsuitability of various orifice locations for the measurement of fluid flow. This company also has set up and in operation a number of meters and its new recording and indicating tachometers.

Several firms manufacturing furnace refractories and arches are exhibiting sections of furnaces as they would be actually set up under a boiler, and pulverized-fuel equipment is represented by the Lopulco pulverizer and group feeder in operation, as well as a Raymond pulverizing mill, one of the Erie City coal pulverizing machines and another of the Aero unit system.

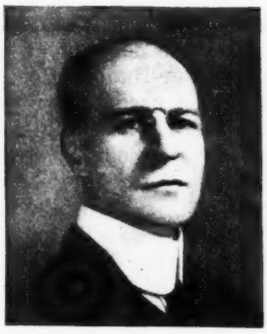
The exhibit of fuels is made up of specimens of the various kinds of fuels—solid, semi-solid and liquid—with complete statement as to origin, and analysis. The solid fuels include all types of anthracite, semi-anthracite, semi-bituminous and bituminous coal. There are specimens of the Virginia anthracite which is beginning to attract attention. The section of solid fuels contains samples of splint and cannel coal, dried peat, wood logs, faggots, wood-mill waste and various forms of briquetted coals. Prepared fuels, such as charcoal and coke, are being shown, as well as powdered fuels. The Bureau of Mines is co-operating in providing samples of domestic coals and some foreign fuels such as Irish peat, Welsh coal and German brown coal.

Among New Devices

One of these is a stream-line filter recently invented by Dr. Hele-Shaw in England, and shown for the first time in this country. This differs from ordinary filters in that the liquid does not penetrate the filtering material, but is passed in these films between laminæ of the material. It consists of a pack of specially prepared paper, impervious to water and oil and somewhat roughened to provide passageways, the pack being held within a container between two press-heads. One of the press-heads is moveable and provided with a screw arrangement for suitably compressing the many hundreds of sheets that make up the pack. Through the entire pack from press-head to press-head are two alternate sets of circular holes, the larger being for the influent and the smaller for the effluent. At one press-head are channels through which, under such pressure as desired, the influent is led to each of the openings of larger diameter, and at the other press-head are channels connecting with the smaller holes in order to remove the effluent. The influent, even under heavy pressure, can

FRED R. LOW
Incoming Pres. American Society of Mechanical Engineers

JOHN L. HARRINGTON
Retiring Pres. American Society of Mechanical Engineers

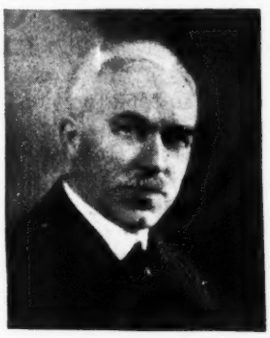


DAVID M. MYERS
Consulting Engineer Griggs & Myers

FRANK W. SMITH
Past-Pres. National Electric Light Association

The Advisory Committee

SECOND NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING



O. P. HOOD
Chief Mechanical Engineer U. S. Bureau of Mines

I. E. MOULTROP, Chairman
Edison Electric Illuminating Co. of Boston

FRED FELDERMAN
Past-National Pres. National Association of Stationary Engineers

W. L. ABBOTT
Chief Operating Engineer Commonwealth Edison Co. of Chicago

N. A. CARLE
Vice-Pres. and Gen. Manager Public Service Production Co.

CALVIN W. RICE
Sec'y The American Society of Mechanical Engineers

E. B. KATTE
Chief Engineer, Electric Traction, N. Y. C. R. R.

CHARLES F. ROTH
Co-Manager Exposition

FRED W. PAYNE
Co-Manager Exposition

JOHN H. LAWRENCE
Chairman Power Division A. S. M. E.

C. F. HIRSHFELD, *Chief Research Department, Detroit Edison Co., is also a member of this committee*

pass from the larger tubular openings only through the laminæ of the heavily compacted pieces of paper with stream-line motion into the smaller tubular openings which form an exit. It is claimed that this filter will extract oil from feed water and will separate water and impurities from oil, extract 30 per cent of the salt in sea water, and reduce dilute activated sludge to a 60 per cent water content. As a result of passing certain mixed liquids through several times and increasing the pressure on the paper pack between each filtration, it is understood that different substances are removed each time, thus accomplishing fractional filtration.

The Uehling Instrument Co. is exhibiting a new form of a carbon monoxide or combustible recorder which will be described fully in a later issue of *Power*.

A new air cooler for installation in the main station generator is being exhibited by the Griscom-Russell Co. This cooler utilizes the turbine condensate as the cooling medium, and therefore the heat that is extracted from the air is saved and the temperature of the turbine condensate on its way to the hotwell is increased from 8 to 10 deg. It is of the surface type, and the cooling of the air is therefore accomplished in a closed system. The cooling surface is formed of rigid U-fin tubes of Admiralty metal with rectangular brass fins. The turbine condensate passes through the tubes, and the generator ventilating air is forced through the cooler casing and is cooled by its contact with the fins attached to the tubes.

Another new device, shown for the first time but which has been described in a recent issue of *Power*, is the automatic fuel-oil shutoff valve of the Tagliabue Manufacturing Co., which, when the air or steam fails, shuts off the oil and keeps it shut off until the trip mechanism is set. This was described in *Power*, Nov. 20.

The Republic Flow Meter Co. is showing for the first time its new boiler indicator and its new draft gages, described in *Power*, Nov. 20, and will have an actual demonstration of the making of the resistance element right in the booth.

The Electrical CO_2 and CO meters recently brought out by the Bacharach Industrial Instrument Co. and described in *Power*, Oct. 2, 1923, form an interesting addition to the line of new recording instruments seen at the show.

A power-operated ash gate embodying a new arrangement of collecting troughs to eliminate flooding of the basement is being shown by the Baker-Dunbar Co. A single stationary collecting trough is used at one end of the gate, and conducting channels at right angles to it are cast integrally with the moving door, insuring passage for the water from all points of the hopper bottom to the collecting trough. These channels are mechanically and automatically cleaned of silt or ash obstruction at each stroke of the gate by scrapers attached to the frame. At the far end of the door is an integrally cast cross-trough of steep pitch leading into the side conducting channels.

Still another exhibit, perhaps not so closely identified with the power plant field but nevertheless of interest to mechanical engineers, is that of a fireless stored steam locomotive built by the H. K. Porter Co. This locomotive in place of a boiler carries a tank containing water heated by steam from a suitable stationary boiler. As steam is used by the locomotive, the temperature of the water and the pressure of the steam in the tank are gradually reduced and part of the water turns into steam. These locomotives are finding a field around the yards of various manufacturing concerns where fire and sparks are particularly dangerous.

Last year the program of motion pictures proved a great attraction, and this feature will be continued. A considerable number of films will be shown by various exhibitors, and the U. S. Bureau of Mines is co-operating with the management in the presentation of two films: "Mining and Preparing Coal for Use" and "Household Economies in the Use of Coal."

In the foregoing, brief mention is made of only a few of the outstanding exhibits. Space does not permit a complete description in this issue, but further descriptions of apparatus exhibited will appear in the report of the show in the Dec. 11 issue. A list of the exhibitors and their products follows:

EXHIBITORS AT THE POWER SHOW AND THEIR PRODUCTS

Booth No.	Manufacturer	Product
319	Aero Pulverizer Co., New York City	Coal pulverizing and burning equipment
8	Alabama Power Co., Birmingham, Ala.	Motion pictures
205	Alberger Heater Co., Buffalo, N. Y.	Heaters, oil coolers and evaporators
75	Allen-Sherman-Hoff Co., Philadelphia, Pa.	A-S-H hoppers and gates
58	American Arch Co., New York City	Suspended furnace arches
65	American Brass Co., New York City	Condenser tubes, brass pipe
48	American Chain Co., New York, N. Y.	
74	American Schaeffer & Budenberg Corp., Brooklyn, N. Y.	Indicating and recording gages and thermometers, tachometers, valves and fittings
80	A. S. M. E.	
74	American Steam Gauge & Valve Mfg. Co., Boston, Mass.	Gages, valves and specialties
217	American Krupp System Diesel Engine Co.	Diesel engines
268	Ames Co., B. C., Waltham, Mass.	Bench lathes, milling and filing machines, dial gages
25	Anaconda Copper Mining Co., New York City	Anaconda products, condenser tubes, brass and copper pipe, rods
95A	Andale Engineering Co., Philadelphia, Pa.	Duplex strainers for oil and water
316	Armstrong Machine Works, Three Rivers, Mich.	Steam traps
312	Armstrong Mfg. Co., Bridgeport, Conn.	Stocks and dies
38	Ashton Valve Co., New York City	Gages, gage testers, master pilot gages
281	Audel & Co. Theo., New York City	Technical books
90	Babbitt Steam Spec. Co., New Bedford, Mass.	Adjustable sprocket rims and specialties
253	Bacharach Industrial Instrument Co., Pittsburgh, Pa.	Electrical CO and CO_2 meters, universal draft gage
54-55	Bailey Meter Co., Cleveland, Ohio	Meters for steam, water, coal air, gas; recording and indicating tachometers
318	Baker R. & L. Corp., New York City	Industrial trucks
16	Baker Dunbar Co., Cleveland, Ohio	Ash hoppers and gates
249	Ballwood Co., The, New York City	Pipe, bends and coils
317	Barnes & Jones, Boston, Mass.	Modulation and thermostatic valves, condensators and traps for heating systems
335	Bassick Mfg. Co., Chicago, Ill.	Lubricators
50-51	Beaumont Co., R. H., Philadelphia, Pa.	Coal-and ash-handling systems skip hoist with simplex loader, suspended steel bunker, weigh larry and cable drag scraper
78	Bernitz Furnace Appliance Co., Boston, Mass.	Clinker-proof furnace wall and blocks
14A	Best Furnace & Burner Corp., New York City	Oil-burning equipment, forge furnaces
70-71	Bethlehem Shipbuilding Corp., Bethlehem, Pa.	Oil-burning equipment "Bethlehem-Weir" single-stage turbo-feed pumps

EXHIBITORS AT THE POWER SHOW AND THEIR PRODUCTS—CONTINUED

Booth No.	Manufacturer	Product
342-343	Boston Gear Works, New York, N. Y.	Gears, sprockets, chains and universal joints
247	Bradley Washfountain Co., Milwaukee, Wis.	Washing and drinking fountains
321	Bridgeport Brass Co., Bridgeport, Conn.	Condenser tubes, brass tubing, rods, sheet, etc.
12	Bristol Co., Waterbury, Conn.	Recording pressure and vacuum gages, electric temperature controls, indicating and recording thermometers and pyrometers
322	Brown Co., A. & F. Co., New York City	Steel shafting, friction clutch, speed reducers, pulleys and gears
28	Brown Engineering Co., Reading, Pa.	Kantilever spring coupling "Jackson" time saving vise, "Brown" stock rack
310	Builders Iron Foundry, Providence, R. I.	Venturi water meters
14B	Bundy Steam Trap Co., New York, N. Y.	Steam traps
A	Burnhorn Co., Edw., New York City	Cooling towers
96-97	Cambridge & Paul Inst. Co. of America, New York City	Electric CO_2 recorders
17	Carling Turbine Blower Co., Worcester, Mass.	Turbine-driven fans and blowers
236	Carr Fastener Co., Cambridge, Mass.	Belt fasteners
79	Cash Co., A. W., Decatur, Ill.	Pressure reducing and regulating valves, expansion and relief valves
14	Celite Products Co., Chicago, Ill.	"Sil-O-Cel" insulating brick and blocks, powder and cements. "Fraxite" high-temperature cements
2	Chapman Valve Mfg. Co., Indian Orchard, Mass.	Valves, fittings and specialties
5	Chase Metal Works, Waterbury, Conn.	Condenser tubing, brass rod, tubing and sheets
344	Clark Co., Jas., Jr., Louisville, Ky.	Motor-driven drills and grinders
260-281-282	Climax Engineering Co., Clinton, Iowa	Gasoline engine-driven A. C. generators, refrigerating machines
67	Cochrane Corp. H.S.B.W., Philadelphia, Pa.	Deaerating heaters, hot process softeners, multiport back-pressure valves and drainers
287	Coen Co., New York City	Oil burners
76	Cokal Stoker Corp., Chicago, Ill.	Hopper-feed hand stoker
53	Combustion Publishing Co., New York City	
92	Connelly Boiler Co., D., Cleveland, Ohio	Water-tube boilers
43	Connery & Co., Philadelphia, Pa.	Steel-plate work, expansion stiffener for metal duct construction
302	Continental Valve & Equipment Co., Framingham, Mass.	Forged fittings and reducing valves
44A	Coppus Engr. Corp., Worcester, Mass.	Steam-turbine and motor-driven blowers, centrifugal turbo boiler-feed pumps
293	Cory & Sons, Chas., New York City	Flow indicators for steam, air and water
79	Craig Damper Regulator Co., Detroit, Mich.	Draft regulators
53	Crane Co., Chicago, Ill.	Valves, fittings and specialties
304	Crosby Steam Gage & Valve Co., Boston, Mass.	Indicating and recording gages, gage testers; safety, blow-down and relief valves
261	Crow Chemical Co., New York City	Boiler compound
311	Dampney Co. of America, Boston, Mass.	Protective coatings for metal surfaces
36-37	Davidson Co., M. T., New York City	Davidson steam pumps
8A	D'Este Co., Julian, Boston, Mass.	Damper regulators, reducing valves and steam regulators
13	Dearborn Chemical Co., Chicago, Ill.	Feed-water treatment—"No Oxid" rust preventive, lubricating oils and greases
275	Dempsey Furnace Co., New York City	Refractories
94	Detrick & Co., M. H., Chicago, Ill.	Suspended furnace arches
222	Detroit Belt Lacer Co., Detroit, Mich.	Metal belt lacing
203-204	Detroit Stoker Co., Detroit, Mich.	Multiple-retort underfeed stokers
78	DeWaters Safety Latch, New York City	Furnace-door safety latch
17	Diamond Power Spec. Corp., Detroit, Mich.	Soot blowers
220	Dick Co., R. & J., New York City	Belting, shafting and steel pulleys
27	Dodge Co., F. W., New York City	Sweets Engineering Catalog
41	Drake Non-Clinkering Furnace Block Co., New York City	Non-clinkering furnace blocks
218	Driscoll Transmission Corp., New York City	Variable-speed transmission
12A	Eastern Steam Specialty Co., New York City	Steam traps and pumps
32	Edward Valve & Mfg. Co., East Chicago, Ind.	Valves, fittings and specialties
272-273-274	Elliott Co., Jeanette, Pa.	Blowoff valves, steam and oil separators, strainers, test kit for measuring corrosiveness of water
44B	Ellison, Lewis M., Chicago, Ill.	Inclined and vertical draft gages
21	Engineer Co., The, New York City	Turner baffle walls, "Enco" oil burners, balanced draft furnace pressure regulators
278	Engineering Magazine Co., New York City	
93	Engelhard, Chas., Inc., New York City	Electric CO_2 recorders, electric resistance thermometers, thermo-electric pyrometers
288-289	Erie City Iron Works, Erie, Pa.	Coal-pulverizing machines
209	Ernst & Co., Newark, N. J.	Boiler gages and fittings
300 & 305	Everlasting Valve Co., Jersey City, N. J.	Blowdown valves
246	Fafnir Bearing Co., New Britain Conn.	Ball bearings
17	Falls Engine Stop Co., Sheboygan, Wis.	Automatic engine stop
339	Falk Corp., Milwaukee, Wis.	Herringbone gearing, conveyor drives, geared oil engines and flexible couplings
15A	Fisher Governor Co., Marshalltown, Iowa	Pump governors, reducing valves and pressure regulators
315	Flexible Steel Lacing Co., Chicago, Ill.	Steel belt lacing
8B	Flint Fire Brick Co., Long Island City, N. Y.	Back combustion chamber arch for H.R.T. boilers
46	Flynn & Emrich Co., Baltimore, Md.	Huber hand stoker
84	Foster Engineering Co., Newark, N. J.	Pressure regulators, non-return valves and pump governors
69	Foxboro Co., Foxboro, Mass.	Indicating and recording gages and thermometers and CO_2 recorders
99	France Packing Co., Philadelphia, Pa.	Metallic packing
95A	Frederick Iron & Steel Co., Frederick, Md.	Spirex vacuum pump
262 & 279	Fuller-Lehigh Co., Fullerton, Pa.	"Fuller-Lehigh" pulverizing mills and burners, "Fuller-Kinyon" pumps and transporting equipment
251	Fulton Co., Knoxville, Tenn.	Temperature regulators and valves
41	Furnace Engineering Co., New York City	Non-clinkering furnace blocks
323	Gifford Wood Co., Hudson, N. Y.	Coal-handling equipment and ice machines
87-88	Gillis & Geoghegan, Inc., New York City	Telescopic hoists for ash removal
303	Girtanner Engineering Co., New York City	Steam ash conveyors and hand stokers
252	Goetze Gasket & Packing Co., New Brunswick, N. J.	Pipe flange gaskets
77	Goodrich Rubber Co., B. F., New York City	Cut less bearings
95A	Gordon, James T. Co., New York City	Strainers, valves and vacuum pumps
35	Graver Corp., East Chicago, Ind.	Hot-process water softeners
334	Graton & Knight Mfg. Co., Worcester, Mass.	Various types of belt drives
23	Green Engineering Co., East Chicago, Ind.	Traveling-grate stoker
201	Green Fire Brick Co., H. P., New York City	Firebrick and refractories
49	Griscom-Russell Co., New York City	U-fin generator air coolers Mirrlees-Watson air ejectors, evaporators, heaters, oil coolers
219	Gurney Ball Bearing Co., Jamestown, N. Y.	Ball bearings
92	Hagan Corp., Pittsburgh, Pa	Automatic boiler-control systems, de-concentrators and heaters
46	Hand Stoker Co., New York, N. Y.	Huber hand stoker and hopper feed stokers operated by hydraulic motors
81	Hays Corp., Jos. W., Michigan City, Ind	CO_2 recorders and draft gages
268	Henry & Wright Mfg. Co., Hartford, Conn.	Viktor dicing and drilling machines
88	Hill Clutch Co., Cleveland, Ohio	Hill collar oiling bearings, friction clutches, rope drives, hangers, shafting, etc.
237	Hobson Co., H. B., New York, N. Y.	Holly gravity return system and boiler accessories
100	Homestead Valve Mfg. Co., Homestead, Pa.	Quarter-turn valves and protected seat operating valves
205	Howard Iron Works, Buffalo, N. Y.	Feed-water heaters and expansion joints

EXHIBITORS AT THE POWER SHOW AND THEIR PRODUCTS—CONTINUED

Booth No.	Manufacturer	Product
221	Howden, Jas. & Co., Inc., of America, Wellsville, N. Y.	Air pre-heaters
81	Huyette Co., Paul B., Philadelphia, Pa.	Hays CO_2 and draft recorder, draft gages and gas analyzers, P.B.H. water gage, damper regulators
278	Industrial Management, New York City	
39	Industrial Power, Chicago, Ill	
278	Industry Illustrated, New York City	
23–24–25	International Combustion Engineering Corp., New York City	Underfeed, overfeed and traveling grate stokers, Lopulco pulverized fuel burner, Raymond pulverizing mill, air heaters and oil-burning equipment
4	International Nickel Co., New York City	Samples of commercial uses for monel metal for power-plant equipment, motion pictures of mining, refining and rolling monel metal
336–337	Jeffrey Manufacturing Co., New York City	Coal- and ash-handling systems
90	Jenkins Bros., New York City	Valves and fittings
76	Jointless Fire Brick Co., Chicago Ill.	"Plibrico" refractories
22	Keasbey & Mattison Co., Ambler, Pa.	Magnesia pipe and boiler covering
28	Kelly Valve Co., Muskegon, Mich.	Self-grinding valves
314	Key Boiler Equipment Co., Philadelphia, Pa.	"Key" safety handhole caps and plates
15B	Keystone Lubricating Co., Philadelphia, Pa.	Lubricators, oils and greases
309	Keystone Refractories Co., New York City	"Dura-Stix" bonding mortar
95	King Refractories Co., Inc., New York City	"Mono" boiler baffles and furnace cements
19	Kissick & Fenno Co., New York City	Soot cleaners and feed water regulators
280	Klingerit Inc., New York City	Stuffing-box packing
91	Ladd Co., Geo. T., Pittsburgh, Pa.	Water-tube boilers
267	Lagonda Mfg. Co., Springfield, Ohio.	Non-return valves, tube cleaners and specialties
223	Laurence Belting Co., New York City	Waterproof and oak tan leather belting
86	Lead Lined Iron Pipe Co., Wakefield, Mass.	Lead-lined pipe and fittings
77	Leather Belting Exchange, Philadelphia, Pa.	Waterproof leather beltings, belt-testing apparatus
273	Liberty Mfg. Co., Pittsburgh, Pa.	Boiler-tube cleaners
232	Liptak Fire Brick Arch Co., Chicago, Ill.	Furnace arches and interlocking firebrick wall
308	Locke Regulator Co., Salem, Mass.	Damper regulators, reducing valves, non-return stop and check valves, engine stop and speed limit systems
23 24 25	Lopulco Co., New York City	Pulverized-coal burners
53	Lunkenheimer Co., Cincinnati, Ohio.	Motor-controlled valves, non-return and safety valves, boiler mountings
13	McLeod & Henry Co., Troy, N. Y.	Flat suspended boiler arch and furnace wall lining
239	McVicker Co., W. B., Brooklyn, N. Y.	Boiler compound
34	Mack Engineering & Supply Co., Inc., New York City	Refractories
271	Maphite Corp., Chicago, Ill.	Furnace-wall coating
60	Manning, Maxwell & Moore, Inc., New York City	Gages, "Consolidated" safety valves, Reeves variable speed transmission
256 257	Marion Machine Foundry & Supply Co., Marion, Ind.	Combined hand and hopper feed stoker, balanced-head soot blowers
40	Manufacturer Record, Baltimore, Md.	
90	Mason Regulator Co., Dorchester, Mass.	Reducing valves, pump, pressure and damper regulators
325	Merrick Scale Mfg. Co., Passaic, N. J.	Scales and weigh larries
269	Merrill Co., The, New York City	Merco-Nordstrum-plug valve
44A	Merritt & Co., L. R., New York City	Boilers, engines and blowers
12A	Metallo Gasket Co., New York City	Valve disks and pipe-flange gaskets
307	Midwest Steel Supply Co., New York City	Air filters, compressors, bulldog timber-join plates
345–346	Morse Dry Dock & Repair Co., Brooklyn, N. Y.	Fuel-oil burners
79	Murphy Iron Works, Detroit, Mich.	Mechanical stoker
66	Nash Engineering Co., South Norwalk, Conn	Compressors and pumps
83	N.A.S.E., New York City	
209	National Co., Boston, Mass.	Water-column illuminators
82	National Engineer, Chicago, Ill.	
93	Neemes Bros., Inc., Troy, N. Y.	Furnace grates
9	Nelson Mfg. Co., Philadelphia, Pa.	Valves, fittings and specialties
340–341	New Departure Mfg. Co., Bristol, Conn.	Ball bearings
245	New England Laboratories, Inc., Springfield, Mass.	Analyses of water, coal, oils, etc.
	Newman Inc., Montrose, New York City	Mantle universal vise
95A	Nicholson & Co., W. H., Wilkesbarre, Pa.	Nicholson controlling valves for air and steam, Wyoming weight-operated steam trap
224	Norma Co. of America, Long Island City, N. Y.	Norma ball bearings and Hoffman roller and ball bearings
19	Northern Equipment Co., Erie, Pa.	"Coppes" feed water regulators
225–226	Obermayer Co., S., Chicago, Ill.	High-temperature cements
57	Otis Elevator Co., New York City	Automatic skip hoist controllers; model of passenger escalator
16	Payne Dean, Ltd., Stamford, Conn.	Motor-operated valves
47	Peabody Engineering Co., New York City	Oil-burning equipment
235	Peerless Machine Co., Racine, Wis.	Universal shaping saws and high-speed hack saws
285	Pennsylvania Crusher, Philadelphia, Pa.	Armorframe single-roll coal crushers
303	Perfection Grate & Supply Co., Springfield, Mass.	Hand stokers
3	Permutit Co., New York City	Water softening and filtering equipment
11	Philadelphia Gear Works, Philadelphia, Pa.	Cut gears
91	Pittsburgh Testing Laboratory, Pittsburgh, Pa.	Laboratory equipment
4	Pittsburgh Valve Foundry & Construction Co.	Valves, fittings and specialties
301	Porter Co., H. K., Pittsburgh, Pa.	Fireless stored steam locomotive
344	Porter Richards Machy. Co., Philadelphia, Pa.	Industrial locomotive
42	Power, New York City	
98	Power Plant Engineering, Chicago, Ill.	
20	Power Specialty Co., New York City	Foster superheaters and economizers
48	Pratt & Cady Co., Bridgeport, Conn.	Valves and fittings
206	Production Machine Co., Greenfield, Mass.	Grinding, surfacing and polishing machines
306	Pyramid Iron Products Corp., New York City	Pyramid grates
89	Quigley Furnace Specialties Co., New York City	Hytempite for bonding firebrick, high-temperature insulation
3	Racine Tool & Machine Co., Racine, Wis.	Machine tools
324	Reading Iron Co., Reading, Pa.	Cast-iron pipe
48	Reading Steel Casting Co., Bridgeport, Conn.	Cast-steel valves, flanges and fittings
207–208	Reed Air Filter Co., New York City	Air filters
81	Reliance Gauge Column Co., Cleveland, Ohio.	Forged-steel water columns
6	Republic Flowmeters Co., Chicago, Ill.	Meters for steam, water, air and gas, draft indicators and recorders; double-face illuminated-dial load indicators
212	Robinson, John R., New York City	Gaskets and power specialties
270	Rooksby & Co., E. J., Philadelphia, Pa.	Boring bars and engine repairs
11	Roto Co., Hartford, Conn.	Boiler-tube cleaners
325	Richardson Scale Co., Passaic, N. J.	Automatic scales and weigh larries
332 333	S.K.F. Industries, Inc., New York City	S.-K.-F. and Hess-Bright ball bearings
10	S. C. Regulator Mfg. Co., Fostoria, Ohio	Feed-water regulators, pump governors and receiver drainage controls
276	Sandnik Steel Inc., New York City	Steel conveyor belts
79	Sanford Riley Stoker Co., Worcester, Mass.	Riley underfeed stoker, lateral retort stoker
30	Sarco Co., Inc., New York City	Steam traps and specialties
62	Scovill Mfg. Co., Waterbury, Conn.	Admiralty condenser tubing, brass sheet, rod, wire and seamless tubing
255	Seminole Chemical Co., Inc., New York City	Method of cleaning boilers
210	Simplex Valve & Meter Co., Philadelphia, Pa.	Indicating and recording boiler-feed meters, indicating manometer
17	Smith Gas Engineering Co., Dayton, Ohio	Gas producers

EXHIBITORS AT THE POWER SHOW AND THEIR PRODUCTS—CONCLUDED

Booth No.	Manufacturer	Product
85	Smith & Serrell, Newark, N. J.	"Francke" flexible couplings "Pintite" rigid couplings, "Keytite" self-fitting keys
10	Southern Engineer, Atlanta, Ga.	
209	Sowdon, W. K., New York City	Gages, high and low safety water columns, inclined water-gage columns, water-column illuminators
28	Spence Co., Paulsen, New York City	"Kantilever" spring couplings, "Cash" reducing and regulating valves, "Craig" draft regulator, Sterling boiler feed systems, lifting and separating traps
31	Springfield Boiler Co., Springfield, Ill.	Water-tube boilers
101	Standard Water System of N. J., Hampton, N. J.	Feed-water heaters and evaporators
28	Sterling Engineering & Mfg. Co., Hyde Park, Mass.	"Sterling" boiler-feed systems, lifting and separating traps
26	Stewart-Sayers Co., New York City	Northwestern boiler control and Diesel engines
283–284	Streamine Filter Corp., New York City	Streamine filters for water, oil and other liquids
320	Sturtevant Mills Co., Boston, Mass.	Grinding mills
56	Superheater Co., New York City	"Elesco" superheaters
27	Sweet's Engineering Catalog.	Engineering catalogs
59	Tagliabue Mfg. Co., C. J., Brooklyn, N. Y.	Indicating and recording thermometers, automatic controllers for pressure and temperature, gas analysis recorder, oil-testing instruments and hydrometers
347	Talcott, Inc., W. O. & M. W., Providence, R. I.	Belt lacing
98	Technical Publ. Co., Chicago, Ill.	
267	Techno Service Corp., New York City	"Borsig" valves
28	Templeton Mfg. Co., Hyde Park, Mass.	Steam traps
73	Tide Water Oil Sales Corp., New York City	Motion pictures; The Story of Tide Water Oil
268	Triplex Machine Tool Co., New York City	Turning and boring; milling, drilling and cutting machines
45	Uehling Instrument Co., Paterson, N. J.	CO and CO_2 recorders, combined barometer and vacuum recorders, Pyros-porous gas filter
265-266	Union Steam Pump Sales Co., New York City	Steam pumps
95A	Union Iron Works, Erie, Pa.	Water-tube boilers
72	United Machine & Mfg. Co., Canton, Ohio	Harrington traveling grate stoker
258	Valve Engineering Co., Cambridge, Mass.	Valves and specialties
17	Vincent-Gilson Engr. Co., New York City	Soot cleaners and turbine blowers
19	Vogt Machine Co., Henry, Louisville, Ky.	Boilers, pumps, refrigerating equipment, drop-forged steel valves and fittings
235	Voss, J. H. H., New York City	
215	Vulcan Soot Cleaner Co., Dubois, Pa.	Soot cleaners
313	Wailes Dove-Hermiston Corp., New York City	Paints and enamels for metal surfaces
8B	Waite & Davey Co., Long Island City, N. Y.	Air-cooled flat suspended boiler arches and furnace blocks
248	Walsh & Weidner Boiler Co., New York City	Return-tubular and water-tube boilers
33	Walworth Mfg. Co., Boston, Mass.	Globe and gate valves, fittings and specialties
250	Warren Webster & Co., Camden, N. J.	Modulation system of steam heating with electric heated steam boiler, feed water heaters, sylphon quick-opening packless valves, boiler return and vent traps
33	Watts Regulator Co., Lawrence, Mass.	Watt feed-water regulators, damper and pressure regulators, pump governors
264–277	Wayne Tank & Pump Co., Fort Wayne, Ind.	Water softeners and oil-storage systems
64	Wheeler Condenser & Engr. Co., Carteret, N. J.	Condensers, evaporators, cooling towers, heaters, steam-jet air pumps, two-stage hotwell pumps
18	Wheeler Mfg. Co., C. H., Philadelphia, Pa.	Condenser, cooling towers Rado-jet air pumps, dry vacuum pumps, dynamometer for testing horsepower of prime movers
263	Wiley & Sons, Inc., John, New York City	Technical books
209	Williams Gauge Co., Pittsburgh, Pa.	Gages, high and low-pressure water-alarm columns; feed-water regulators
61	Wing Mfg. Co., L. J., New York City	Turbine blowers
	Wolner, Dr. O. H., Eleor, Minn.	Improved steam turbine
259	"X" Laboratories, New York City	"X" Liquid for repairing leaks in boilers and hot-water systems
7	Yarnall-Waring Co., Philadelphia, Pa.	Motor-operated blowoff valves, V-notch meters, spray heads, steam traps and unloaders

Oil-Engine Lubrication

One of the main causes of complaint in the lubrication of Diesel engines is found to be carbon deposits in the cylinder. Generally, the lubricating oil is blamed for this, when in the majority of cases it is the fault of the operator, due to his using a greater amount of oil than necessary for proper lubrication. An over-supply of oil in these cylinders causes a formation of carbon.

The amount of oil necessary to lubricate the cylinders of a Diesel engine depends on many factors, and it is necessary to solve each individual problem as to the quantity required. The color of a Diesel engine oil has little or no relation to its lubricating value. The best results will be obtained with a Diesel engine equipped with a forced-feed lubricator, and it is advisable to adjust the feed pump so that the pump plungers work in synchronism with the engine pistons, the oil being delivered directly onto the pistons, between the rings and at the end of the stroke. Oil that does not strike the pistons or that is forced into the cylinder at such a time as the oil outlet holes are uncovered by the piston is wasted and results in carbon formation. In some cases the lubricator may be so divided that one grade of oil may be supplied to the cylinder and another grade to the bearings.

Knocking in Gas-Engine Cylinders

Knocking in a gas engine is a noise that sounds like a hammering of one part against another part. In addition to mechanical knocks, there are carbon knocks, spark knocks, preignition and "pinking." It has been found through optical indicator diagrams that these knocks, excluding mechanical ones, are due to fuel conditions and that they are increased in intensity by early spark, carbon deposits and high compression.

The knock occurs after ignition and causes a sudden rise in pressure at upper dead center, followed by a rapid fall in pressure. While it is usual to assume that preignition takes place very early in the compression stroke, in fact the piston is usually at the top of the stroke before the pressure wave occurs.

CONDENSING-WATER REQUIREMENTS OF STEAM POWER STATIONS—Fig. 3 on page 748, Nov. 6 issue, is in error in that it gives the cubic feet of water ten times what it should be. This article was abstracted from a paper, printed for presentation at the Chattanooga meeting of the American Society of Mechanical Engineers, in which the mistake was originally made in the reproduction of the manuscript.

R. H. Macy Power Plant Changes from Coal to Oil Burning

Six of Eleven Coal-Fired Boilers Change Over to Oil Burning, Which Will Result in an Ultimate Saving of Approximately $50,000 a Year and Provide Additional Capacity Required for New Store

WHEN in 1921 R. H. Macy & Co. considered enlarging its department store at Sixth Avenue and Thirty-fourth Street, New York City, one of the first problems to be solved was how to supply heat, light and power to the new addition. In the store, which at that time had a total floor area of about 1,100,000 sq.ft., there was a power station that was giving excellent service as to economy and reliability, being able to generate power over a yearly period considerably cheaper than it could be purchased. This plant consisted of eleven coal-fired water-tube boilers having a total heating surface of 30,000 sq.ft. and five Corliss-engine-driven and one high-speed-engine-driven direct-current generating units, having a total capacity of 2,000 kw. As the new building would increase the floor area by about 450,000 sq.ft., it was necessary to provide about 50 per cent more power and heating equipment; therefore it was decided to make a thorough investigation of the whole problem, and to this end Werner Nygren, consulting engineer, of New York City, was retained to make a preliminary report on the boiler plant. The findings resulting from this study led to a decision to change over to oil fuel.

Cost of Making the Change

The fuel costs used in this study were 4c. per gal. for oil and $6.70 per ton for coal delivered, both of which could be contracted for at these prices. A two-year contract for oil was considered necessary to warrant the change. With the present plant it was estimated that a saving of approximately $40,000 a year could be made. Of this amount $16,000 resulted from reduced labor costs and $3,000 for ash removal. With a plant capacity to meet the requirements of the enlarged building, the saving was estimated to be about $50,000, of which over $20,000 was in labor costs and nearly $4,000 for ash removal.

It was found that the boiler plant had ample capacity to take care of future power needs with coal firing. With oil firing the boilers could be operated at about 150 per cent rating, and this would allow carrying the load on five units. Providing one as a spare, it was necessary to equip only six of the 11 boilers for oil burning, which made it possible to keep the installation cost down to two years' saving in operation. The change to oil burning has been made, and the results of operation show that the estimated saving will be materially exceeded. Oil fuel has other advantages in this installation aside from the resulting economy; it does away with the inconveniences associated with coal burning and it also simplifies the labor problem.

The boilers, as installed for coal firing, were set five feet above the grates which today would be considered too low for best results with coal firing, and oil firing requires even a higher setting. Removing the grates increased the furnace height about one foot, and an additional foot was gained by blasting the rock away from under the combustion chamber, so that now the lower rows of tubes are seven feet above the bottom of the combustion chamber. On account of the clearance above the boilers, it was not possible to raise them to increase the combustion-chamber volume. The oil-equipment manufacturers were willing to apply their burners to the low coal-fired furnaces, but the engineers advised against this, as it was felt that there was danger of damage to the lower rows of tubes and also that a higher setting would tend to improve the efficiency of combustion. Furthermore, there was the possibility that oil burning would be retained indefinitely. It was therefore of importance to install the equipment in a manner to insure economical and safe operation. To this end the combustion chambers were enlarged and the furnaces relined and new and suitable fronts installed.

On each of the 2,500- and 2,900-sq.ft. boilers there are installed two burners of the mechanical atomizing type, with burner tips of 490 lb. per hour capacity, and on the 4,300-sq.ft. boiler three of these burners are installed. Oil is pumped from the service tank and heated to a temperature of 240 deg. F. and delivered to the burner at a pressure of 150 lb. per sq.in. Heating the oil is done with live steam, and the heater has a daily capacity of 8,000 gal. from 80 to 250 deg. Hand control is used and is arranged so that the supply of fuel to all boilers can be regulated by a common valve, or each boiler can be regulated by valves in the return lines from the burner. A feature of this burner is that oil pressure is maintained constant at the burner under all loads and the excess oil due to variation in load is bypassed to the service tank.

Arrangements Made for Storing Oil

In this installation the most economical arrangement for storing the oil would have been to place two 20,000-gal. tanks in the coal bunker under the sidewalk and a 17,000-gal. tank in the sub-basement of the new building, and this was what was originally planned, if the city ordinances could be satisfied. This arrangement would have made use of the space occupied by the coal bunker in the old building and would have utilized a minimum of space in the new building. When the plans for the change over were finally drawn up, however, it was found advisable to make some modification of this scheme, so that a reserve storage of 80,000 gal. has been provided in four 20,000-gal. tanks in the sub-basement of the new building and a service tank of 17,000 gal. in the coal bunker on a level with the boiler-room floor. This storage is sufficient for about three weeks' operation. The main objection to storing oil in the coal bunker was that the city ordinance requires that the oil-storage tanks be below the level of the boiler-room floor. The oil tanks are vented to the roof of the present store by

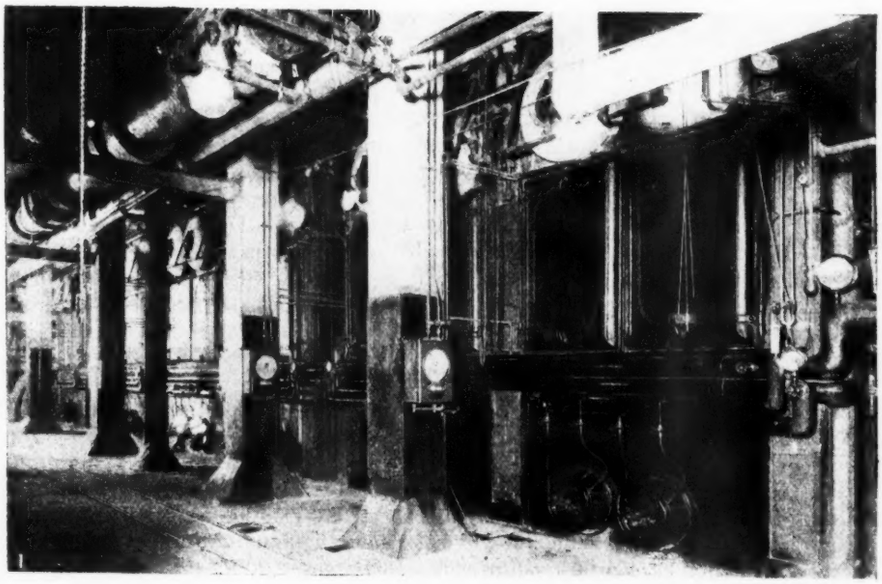
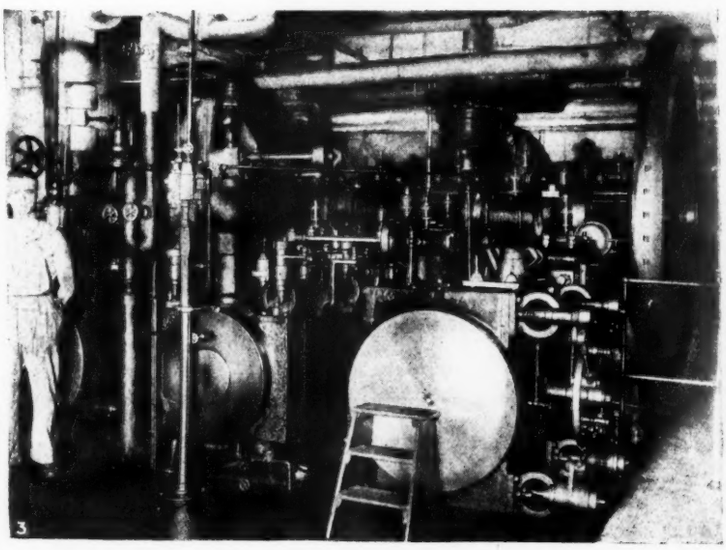
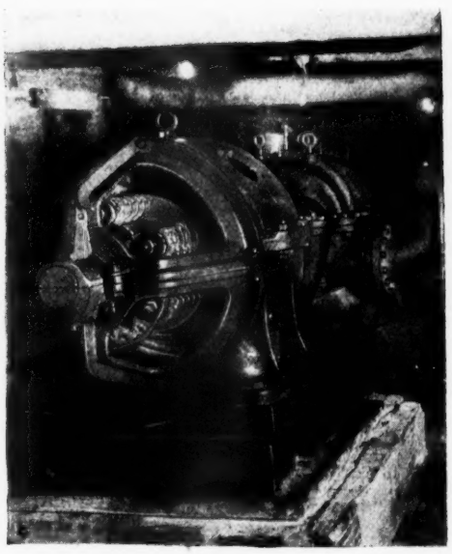


Fig. 1—Six boilers converted from coal to oil burning. Each 2,500-sq.ft. boiler has two burners equipped with tips of 490-lb. capacity each per hour. A 4,300-sq.ft. boiler has three such burners.

Fig. 2—Looking from inside of one furnace toward the oil burners. Shows high-temperature cement mixed with old crushed firebrick applied around the burners to protect the brickwork.

Fig. 3—Triplex compound elevator steam pump of 3,000 gal. per min. replaced by the motor-driven centrifugal pump, Fig. 4, at a saving that will pay for the change in five years.





a 3-in. pipe from each tank, since the city ordinance requires that no vent pipe can discharge within five feet of any window and this regulation could not be complied with without going to the roof. The oil-tank enclosures also are vented to comply with city ordinances.

Other Mechanical Features of the Plant

On the mechanical end of the plant as it is being rebuilt, there are a number of features of particular interest. The power-generating equipment is being changed over from 115 to 230 volts and the capacity of the plant increased from 2,000 to 3,000 kw. This work is under the direction of Kaiser, Muller & Davis, consulting engineers, New York City. Exhaust steam is used for heating the building and for other purposes, such as heating water for domestic service, warming air for ventilation, etc. In the winter the maximum load will require all the exhaust steam from the engines at about 1 lb. back pressure. The engines exhaust into two 20-in. mains which unite into a 24-in. vertical line that runs directly to the roof above the nineteenth story of the new building. This line contains a multi-port back-pressure valve near the roof, which can be operated electrically from the chief engineer's office to control the back pressure and to a degree the amount of exhaust steam. A branch is taken from the exhaust-steam piping to the sub-basement for heating the original building. At the eighteenth story a branch is taken off the vertical exhaust pipe for heating the new building, and at the tenth story a second branch is taken off for tempering the air in the ventilating system, which in the winter time is raised to 65 to 70 deg. F. before being distributed through the building. At the ninth story a second branch is taken from the vertical exhaust line, which is connected with the tops of all risers in the original building and reinforces the steam supply through these risers. The ventilating fans for fresh-air supply and several exhaust fans are on the roof of the original building; the principal exhaust fans are in the nineteenth story of the new building. A total fan capacity of 1,700,000 cu.ft. per min. is provided. Of this about 900,000 is in fresh-air supply fans and 800,000 in exhaust fans, the largest of which has a capacity of 200,000 cu.ft. per min. Approximately 1,000 hp. motor capacity is installed to drive these fans.

The basement and sub-basement of the new building will be used for a service loading room. The delivery trucks will be loaded on these floors, and while loading, their batteries will be charged. On this account the exhaust air from this portion of the building will contain acid fumes that must be guarded against in the air ducts. The exhaust ducts from the service loading rooms are in part of masonry or asbestos-wood construction, and wherever metal work is used all parts are painted with acid-resisting paint. The main air duct, which runs vertically from the sub-basement to the roof of the new building, is provided with smooth cement finish on all inside surfaces.

Refrigerating Plant and Pumps

Other features of the installation are the 110-ton compression-type refrigerating plant and the pump installation for the hydraulic elevators. The pumping equipment for the latter service originally consisted of two 3,000-gal. per min. compound triplex pumps and one 750-gal. per min. compound-duplex pump. These are being replaced by one 2,200- and two 1,500-gal. per min. motor-driven 4-stage centrifugal pumps and one 325-gal. per min. two-stage centrifugal pump. The saving in labor, maintenance, lubrication and power is estimated to pay the installation cost of the entire change over ($32,000) in five years; besides, the space made available by the removal of the triplex pumps will be available for other purposes.

The work of changing over from 115 volts to 230 volts is now nearing completion and will be the subject of another story.

Power wishes to express its appreciation for the assistance rendered in the preparation of this article by Werner Nygren, consulting engineer, on all steam and mechanical equipment with the exception of the steam engines, generators and elevators; to Kaiser, Muller & Davis, consulting engineers on the generating units, electrical and elevator equipment; and to Thomas Brennan, chief engineer, John Cogan, assistant chief engineer, for R. H. Macy & Company.

DATA ON NEW EQUIPMENT IN R. H. MACY'S PLANT

OIL BURNING EQUIPMENT

Manufacturer	Peabody Engineering Corp.
Type	Mechanical atomization
Capacity per hour, lb. per tip	490
Number, two on each 2,500-sq.ft. and 2,900-sq.ft. boiler; 3 on 4,300-sq.ft. boiler	
Pumps	Worthington Pump & Mach. Corp.
Heaters	Griscom-Russell Co.
Strainers	Elliot Co.
Storage tanks	Dover Boiler Works
Pneumereator	Pneumereator Co., Inc.

BOILER SETTINGS

Height of steam-drum center from firing aisle floor	13 ft. 6 in.
Height from center of burner to nearest tubes	4 ft. 4 in.
Height from bottom of combustion chamber to nearest tubes	7 ft.
Firebrick	Queens Run Firebrick Co.
High-temperature cement	King Refractories Co.

STEAM ENGINES

Manufacturer	Hooven Owens, Rentschler Co.
Number	1
Capacity	750 kw.
Type	Corliss tandem compound
Speed	100 r.p.m.
Manufacturer	Erie Ball Engine Co.
Number	1
Capacity	250
Type	High-speed Corliss
Speed	150

REFRIGERATING EQUIPMENT

Manufacturer of compressors	Voss Ice Machine Co.
Number and capacity	Two 30-ton, one 50-ton
Drive, direct-current motor belt connected by	Lenox drive
Brine coolers	Henry Vogt Machine Co.

MISCELLANEOUS

Air compressors	American Air Compressor Works
Electric elevators	Otis Elevator Co.
Hot service-water heaters	Patterson Kelley Co.
Fire, service, elevator and sump pumps	Worthington Pump & Mach. Wks.
Heating system vacuum pumps	Nash Engineering Co.
Soot blowers	Diamond Power Specialty Corp.
Multiport back-pressure valve	Cochrane, H.S.B.W. Corp.
Valves	Jenkins Bros.
Valves	Lunkenheimer Co.
Valves	Ludlow Valve Mfg. Co.
Reducing valves on air	Leslie Co.
Reducing valves on steam	Mason Regulator Co.
Boiler meters	Bailey Meter Co.
Oiling system	Richardson-Phoenix Co.
Oiling system on 250-kw. engine	Hills McCanna Co.
Lenox drive on refrigerating machines	F.L. Smidth & Co.
Pump governors, on ice water, brine and house pumps	Ford Regulator Corp.
Pressure gages	Schaeffer & Budenberg Mfg. Co.
Pressure gages	U. S. Gage Co.
Thermometers	A. E. Moeller
Thermometers	Tagliabue Mfg. Co.

New generators were supplied by Crocker Wheeler Co.; motors by General Electric Co., Crocker Wheeler Co., and Westinghouse Elec. & Mfg. Co.; motor automatic starters, Sundh Electric Co.; switchboard, Metropolitan Engineering Co.; switchboard meters, Western Electrical Instrument Co.; Sangamo Electric Co., and Esterline-Angus Co.; circuit breakers, Cutter Electrical and Manufacturing Company.

EDITORIALS

F. R. LOW, EDITOR

Following the Manufacturers' Standards

ONE of the factors responsible for the relatively low-priced automobile and the tremendous expansion of that industry in this country, as compared with the more restricted use and higher prices abroad, has been the degree of standardization employed in the American product in contrast to the practice of catering to the purchasers' individual tastes, as in the foreign machines.

While there may be no direct comparison between the automobile industry and the design of power plants, still the experiences of the former may serve as a lesson that can be followed profitably in the latter case. That is, there appears to be an all too prevalent tendency for engineers to give full rein to their originality and specify their own ideas regardless of what or how good the manufacturers' standards may be. This is especially true with regard to small matters. It not only incurs needless delay and increases the manufacturer's difficulties, but also materially adds to the cost of the equipment. Of course it is not inferred that engineers should follow the same standards to the point of impeding progress and improvement in power-plant design, but it is bad commercial engineering to insist on the inclusion of something just because it is different.

A Mass Attack on the Heat Cycles

IF THE heat cycles have any secrets left by the end of this week, it will not be the fault of the A. S. M. E. Never has an attack been more carefully planned than that to be staged at the annual meeting's power session, on Dec. 6. The amount of study and discussion devoted to these subjects during the last twelve months has been phenomenal. This is as it should be if the new developments are wisely to be built upon the solid foundation of engineering analysis. Investments totaling millions of dollars should not be entered upon without due consideration of all the important factors.

It is fortunate that much of this study has taken definite shape in the four remarkable papers on heat cycles to be presented at this session. Differing somewhat in method and points of emphasis, these papers all lead to valuable and fairly definite conclusions as to the gains to be expected from higher pressures, special cycles and other methods of increasing plant economy.

That by E. L. Robinson, being the shortest, most general and most elementary in its treatment, should preferably be read first. From this paper the reader can get a birdseye view of the ultimate possibilities, even to the point of employing a three-fluid cycle of mercury, water and ammonia. He will learn something of the relative advantages of reheating, regenerative heating, moisture removal and higher pressures.

With this general view as a foundation more specific practical details can be obtained from the other papers. That of Brown and Drewry explains in great detail a standardized method of computing the performance of bleeder-heater systems. It then applies this method to the solution of definite problems.

In his paper on reheating, W. J. Wohlenberg compares the reheating, regenerative and combination cycles over a wide range of pressures. He finally arrives at the specifications for a station with an economy of 12,000 B.t.u. per kilowatt-hour.

Hirshfeld and Ellenwood, in what is perhaps the most comprehensive paper of the group, canvass the entire field three times—first for the purely theoretical cycles, next for actual expected economies, and finally, for commercial economies reduced to the total cost per kilowatt-hour including investment charges.

The authors are in substantial agreement that the present practical limit of temperature is around 750 deg. F. and that the most desirable pressures for all the proposed cycles lie well under one thousand pounds. All are inclined to favor bleeder heating over reheating except Professor Wohlenburg, who seems to prefer reheating. All agree that a combination of reheating and regeneration will save more fuel than either alone, but opinion is divided as to whether the combination cycle is commercially superior to the straight regenerative cycle.

These differences of opinion will doubtless be threshed out in the discussion, which promises to be lively. The A. S. M. E. is to be congratulated for its share in crystallizing engineering opinion upon such timely and important questions.

Factors in Power Plant Development

IT IS only a short time ago that steam engines operating with one hundred and fifty pounds steam, no superheat and twenty-five inches of vacuum were considered standard equipment for power plants. Plant engineers were practical men who had learned by experience how to indicate engines, to set valves and to adjust bearings. They were generally content with their equipment so long as steam was generated and power delivered. Then came into play two factors that entirely altered the trend of power-plant development and whose ultimate effect can only yet be conjectured. These factors were the steam turbine and the technically trained engineer, and to these may be credited the remarkable developments that surprise one in every new power plant.

Men with college training have been forging ahead quite rapidly in the organizations of the large power companies, and many now hold leading positions. These men were thoroughly drilled in thermodynamics and heat engines during their college courses and also had had a spirit of inquiry awakened by their laboratory work. In the power plant they at once attempted to apply these principles to the machines they found

in use. They delighted in tests and in hunting down stray B.t.u. losses, with the result that the operation of boilers, heaters and other equipment was steadily improved. They have also inaugurated much research and have been ready to accept and try out any new equipment that seems fundamentally sound in theory and correct in design; in fact, they have demanded many of the new instruments to aid in maintaining efficiency. They have confidence in their ability to analyze problems and to apply the results of such analysis. Hence these men are ready to try out new heat balance or other coal-saving plans. Many of them share in the activities of the national engineering societies and and have contributed valuable papers and other work to those organizations.

Much of what has been accomplished would have been impossible but for the advent of the steam turbine. The steam turbine fortunately conforms more closely to theory than does the steam engine; hence the laws of heat and of mechanics were easily applied to its design by the technically trained engineers employed by the companies building these units.

A third factor has exerted a great influence during the last few years and that is the late World War. For at least two hundred years war has acted as an accelerator to technical development. The Industrial Revolution in England was coincident with the Napoleonic Wars. The rapid growth of the metal-working industries of Pennsylvania and New England followed our Civil War. The late World War brought the submarine and the airplane to high stages of development. The World War and its economic effects have spurred power-plant engineers to attempt changes that would have been made only after long deliberation under earlier conditions. One is astounded at the rapid acceptance of such daring innovations as pulverized fuel, twelve-hundred-pound steam pressures, extremely high superheats, and fifty thousand kilowatt single-cylinder steam turbines. Boiler and economizer efficiencies of ninety per cent and better are being talked about, and new schemes of heat balance to save coal are considered almost daily.

One is indeed fortunate to be living in these stirring times and to have a hand in these epoch-making advances. The end is not yet. Every engineer owes it to himself to follow closely developments in theory or in practice in order to keep abreast of the procession. The sessions of the Power Division of the American Society of Mechanical Engineers this week offer him new theory, while the Power Show is an opportunity to see new machinery. Why not take in both?

Necessity vs. Economy in the Power Plant

AS GREAT as the improvements in design and operation of power plants have been, for the most part they have been made in new plants or in old ones to obtain more capacity. It is seldom that an old plant is rebuilt for the single purpose of improving efficiency, even though such a change would result in a saving that would pay the total cost of reconstruction in a few years. Not infrequently, statements are published regarding the enormous savings that have been made by rebuilding plants, but the primary purpose behind these, for the most part, was to obtain additional capacity, improved operation and efficiency being secondary.

This same condition is found in the component parts of the plant; things have been done to a large degree by necessity rather than for efficiency or economy. Safety valves and pressure gages have been associated with steam boilers from their earliest use, and the automatic governor for the steam engine came into existence at an early date and has ever since been a part of engines in their various forms. These devices were absolutely necessary to the safety of the equipment and to life and property around them.

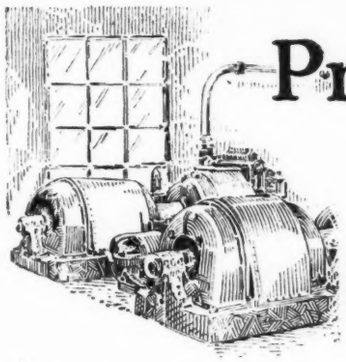
How different the conditions are that attend the other features of power-plant operation! It is only within comparatively recent years that devices for obtaining an intelligent record of the plant's operation have been seriously considered. The boiler plant has usually been looked upon as a dirty place, one to be avoided. It is now generally realized, however, that it is the place where the greatest operating economy can be made in the plant by proper attention. Boiler operation is the most complicated of any in the plant, yet how frequently it is left almost entirely in the hands of men whose only qualifications are their ability to shovel coal into the furnace and in some way manage to keep the steam pressure up. What it might be costing to do this or how much could be saved by providing means of obtaining an intelligent understanding of the plant's operation and employing the right kind of men to make proper use of this information is given little or no attention.

The time is past when power-plant devices for obtaining records of and for controlling operation are an experiment. They have reached the stage in their development where they can be relied upon, with a reasonable amount of intelligent care, to give reliable service. The savings that can be made by the proper use of these devices are no longer theories but facts established by years of operation under exacting conditions. What is now needed in many of our plants is a new kind of thinking based on economy and not on necessity, and the findings of this thinking put into action.

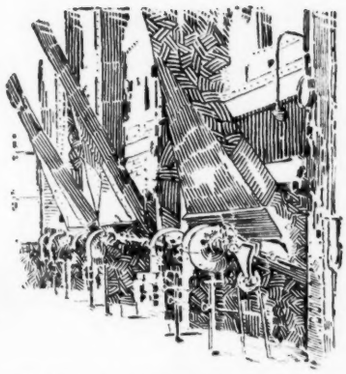
The Value of Figuring Your Heat Balance

A BALANCE sheet can be prepared for any business, successful or unsuccessful. In the same way a heat balance may be worked up for any power plant, good, bad or indifferent. The term heat balance is here used in its original sense as an accounting for the heat that enters with the fuel.

Not only does every plant have a heat balance, but it also has an engineer who is presumably working to advance himself. As likely as not he has read articles on heat balance and has a general idea of how to figure the amount of heat in fuel, that lost up the chimney, that delivered as power at the bus, that lost through the engine exhaust, etc., but the strong probability is that he has never worked out a heat balance for himself. Until he does this, he will never have a really thorough knowledge of the subject any more than he would be fully competent to fire a boiler if he had never put his hand to a shovel. It is worth any engineer's time to figure out a rough heat balance of his plant, showing the distribution of the main currents of heat. Two or three hours of such work will help him wonderfully in his subsequent reading and in his efforts to improve the efficiency of the plant.



Practical Ideas *from* Practical Men



Designating Power-Plant Equipment

For reasons too numerous to mention, it is highly advisable to designate, by a letter, number or name, all valves, pumps, compressors, accumulator tanks, generators, transformers, etc., found in a power plant. The advantages of designating station equipment would seem so evident as to be universally followed, yet in some hydro-electric stations designations of equipment are conspicuous by their absence. It is but fair to add, however, that in the majority of such stations some system of apparatus designation has been worked out and put into effect.

The method usually followed is to paint, in white, red or black, the designation directly on some conspicuous part of each piece of equipment. The objection to this method is that the paint is likely to be worn away in a short time, obliterating the designation. The result is that frequent repainting is usually required, and unless the work is done by a sign painter instead of by handy members of the operating force, its appearance is likely to be decidedly poor. With the aid of a stencil outfit, signs, etc., of fair appearance can be made, but stenciled work does not compare favorably with that done by a sign painter. Since some plants are so located that the expense of bringing a sign painter to the work may amount to more than the cost of painting, it is evident that the cost of maintaining painted designations is likely to be high.

The use of copper- or nickel-plated numbers or letters offers one method of eliminating painted designations, but such metal figures are not, because of their limitations of space, suitable for use on small valves and equipment of similar dimensions. Metal figures can be used to advantage, however, for designating large apparatus, such as generators and transformers.

Enameled name-plates and signs have been extensively used in a few power plants, and as these signs can be obtained in almost any desired size, they may be used to designate practically any piece of apparatus. As enameled signs are not subject to rapid deterioration and their appearance is excellent, they may be used wherever a sign made of conducting material is not objectionable.

In some plants the designation is stampel on the bodies of small valves, and this method is satisfactory provided the valve is not damaged. A better plan seems to be to attach a small enameled or engraved plate to the valve. Cheap stamped plates are found attached to valves in some plants, but their appearance condemns their use.

There are numerous places where signs should appear in any power plant, some of which are on doors, in bus rooms, and on switch compartments, and the enameled sign appears to be most suitable for this general station use, as well as for designating piping, tanks and other equipment requiring more than one or two figures.

Caribou, Calif. RALPH BROWN.

The American Complex

Returning travelers frequently both amuse us and fill us with wonder with accounts of the strange obsessions held by out-of-the-way tribes and races. The life of certain tribes is made up of a race to see which member has his hut filled with the greatest number of human skulls, while others hold ideas equally worthless. Such practices might well be termed *tribal* complexes.

But are the American people free from a complex, even though of less revolting form? A visitor, if he were to study the habits of the community to find the underlying motive, would undoubtedly conclude that we are suffering from the "immensity complex."

Regardless of what business one pries into, it will be found alive with the desire to do things that are big in a dimensional sense. The profitable one-ring circus has an ambition to be transformed or consolidated to form a three-ring and side-show affair, even though at a loss of profit.

This complex has afflicted itself upon the engineering world until an engineer is considered as living in the past if he talks in terms of less than a hundred thousand kilowatt plants. Discussions in the several publications, as well as those before the engineering societies, deal only with the large installations to the utter exclusion of the more modest plants, upon which the expenditure of even a modicum of effort would show a hundred-fold return.

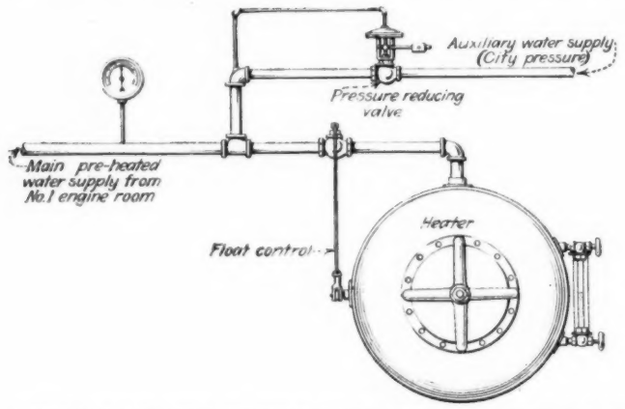
Seriously, should not engineers give more attention to the industrial plant? While the great central stations are carrying a large load, the fact remains that the majority of the industrial load of the country is supplied by isolated plants. These plants are not operated as efficiently as are the large central stations, and the opportunities for savings are correspondingly great. But few engineers will claim that the average efficiency of all central stations can be increased more than 1 or 2 per cent save through either complete remodeling or the installation of new equipment. As against this, the consensus is that a saving of from 10 to 50 per cent in operating costs in industrial plants is a possibility.

While in no way lessening the effort to reduce costs in the large plants, engineers should give more attention to those small plants whose output turns the wheels of industry. JOHN CASSIDAY.

Jersey City, N. J.

Pressure Reducing Valve Regulates Auxiliary Water Supply to Heater

Some time ago the company with which I am connected found it necessary to provide means for heating the feed water to a higher temperature. The plant is arranged with two engine rooms, one of which is approximately 1,200 ft. from the main boiler room. At No. 1 engine room there was a considerable surplus



AUXILIARY WATER SUPPLY TO HEATER IS CONTROLLED BY PRESSURE ON PUMP DISCHARGE

of exhaust steam, while at No. 2 there was not sufficient exhaust to heat the feed water.

Two courses were open, either to run a large pipe line to convey the exhaust steam to the heaters at No. 2 engine room or to heat the water at No. 1 engine room and run a much smaller line to carry the preheated water to the heater. The first plan was objectionable on account of its cost and the additional back pressure it would put on the engines at No. 1 engine room. It was finally decided to install a heater at No. 1 engine room and pump the preheated water at about 150 deg. F. into the heaters at No. 2 engine room, where it would be raised to about 210 deg. by the exhaust steam available there. This arrangement, however, had the disadvantage of being dependent upon a pump that was located a considerable distance away. We therefore devised a means for automatically turning in an auxiliary supply of water to the heater in case of failure of the supply from No. 1 engine room. This was accomplished by means of a reducing valve installed as shown in the illustration.

As soon as the pressure in the water line from No. 1 engine room falls below the pressure at which the reducing valve is set, the water is automatically turned on from the auxiliary supply. A. D. DOWNING.

Ottumwa, Iowa.

What Is the Record Non-Stop Engine Run?

No doubt many engines in different parts of the world are running many months continuously without a stop of any sort, so that it would be interesting to know what is the record. We have in our plant regular runs of six months and on one occasion eight months, but this is a modest performance compared with the following, which I discovered in a paper of twenty years ago in my possession.

This account refers to an engine manufactured by Messrs. Fowler's, of Leeds, England, and installed in the works of the Smelting and Refining Company of Australia, Dapto, New South Wales, and is of 250-i.hp. compound condensing. It had at this time completed six years' continuous run of twenty-four hours a day without a stop of any kind, the run totaling a distance of 2,198,760 miles, and it was still going.

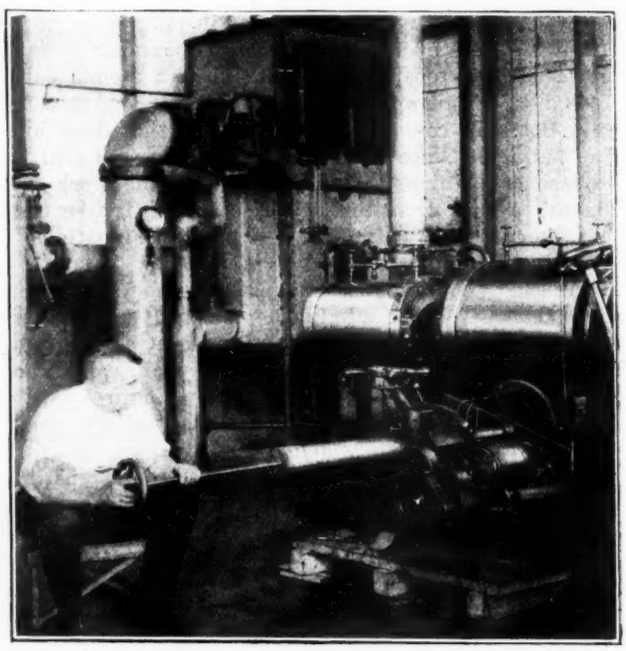
This remarkable performance was given out by the chief engineer of the company at the time, and it would be interesting to know if a better record can be given, particularly with any engine of more recent manufacture, the engine in question being manufactured nearly thirty years ago. F. P. TERRY.

Belfast, Ireland.

Driving Boring Bar a New Use for Pipe Machine

The accompanying photograph taken at the plant of the Singer Manufacturing Co., Bridgeport, Conn., shows a new use for a pipe machine, and it occurred to me that it might be of interest to readers of *Power*. The cut illustrates the boring out of a valve cylinder on a Ball & Wood Corliss-valve engine by means of a pipe-threading machine.

A collar made to slip over the threading dies was inserted in the machine and a key on the interior surface of this collar transmitted the power to the boring bar, which had a long keyway cut in one side allowing it to be fed forward. The rear end of the boring bar extended into the piece of pipe, which was clamped into the vise of the pipe machine and the feed was obtained by means of the hand-operated feed screw which



PIPE MACHINE IN POSITION FOR DRIVING BORING BAR

was tapped through the cap on the end of the pipe. Of course suitable guides, as shown, were provided on each end of the valve cylinder. The cylinder was about 15 in. in diameter and 20 in. long, and the job was done in one cut, about ⅛ in. in diameter being removed. There are several other engines of this type in the power plant, and they expect to rebore them all by this method. E. L. W. CURTIS,

Bridgeport, Conn. The Curtis & Curtis Co.

Comments from Readers

Thermometers in Refrigerating Plants

The statement in the Questions and Answers page of *Power*, Oct. 23, on the placing of thermometers in a refrigerating plant is correct as far as it goes, but I think it could be made more complete.

If the plant has a liquid cooler, a thermometer should be placed in the liquid line between the receivers and the liquid cooler and another between the liquid cooler and the expansion valves. The difference in the readings of these thermometers indicates the amount of heat absorbed by the liquid cooler from the liquid ammonia.

If the plant is a combination of ice tanks and storage rooms, as most plants are, it is difficult to work comprehensively from the readings of the thermometers in the suction lines at the machines, and the gage readings are not very good indications of the coil temperatures. For instance, if the tanks are carried at 10 deg. and the storages at 25 deg. F., the gage readings will change in accordance with the position of the expansion valves for the tanks and storage rooms. Of course there should be thermometers in the suction lines at the machines, but in order to get the best results from the power consumed and the plant in general, they should also be placed in the suction lines leaving the tanks and before the main suction headers from the storerooms and tanks combined. These thermometers will indicate the exact condition of the gas from the tanks and will be a great help to the operator. M. E. BELL.

Riverbank, Calif.

Improving Plant Operation by Correcting Power Factor

In connection with the editorial in the Nov. 20 issue on the "High Cost of Low Power Factor," there is another side of this question which was not touched on, probably because less frequently encountered, but fully as important. This is the increased capacity possible with old-type engine-driven alternators designed for unity power factor and having field capacity insufficient for excitation at low power factors.

At a coal mine where I worked, the station equipment consisted of a 2,500-kw. turbine unit at 80 per cent power factor, a 1,200-kw. turbine unit at 80 per cent power factor and two 400-kw. cross-compound Corliss-engine driven generators for unity power factor. Under ordinary conditions the 2,500-kw. turbine would carry the load alone, but when it was down for overhauling, it was difficult to carry the load on the remaining units. From a casual inspection of the switchboard instruments it was seen that the engines were not taking their share of the load, and they were indicated and some slight valve adjustments made. The cards corresponded reasonably well to the power developed, as there was only one indicator for two cylinders and the load was quite fluctuating, but the adjustments made no appreciable improvement in the load carried.

In order to get more exact data on individual unit performance, readings of all switchboard meters were taken as frequently as possible for periods of 30 min., averages of which are given in the two left-hand columns in the table. From this table it can be seen that the cross-current in the two engine generators keeping them in phase was reducing the power factor so low that, notwithstanding a fairly favorable system power factor and the high power factor of the turbine generator, the exciter could not supply enough current even at 150 volts to carry the load over the peaks without the engines' dropping so much of the load onto the turbine as to slow it down and at times cause dropping part of the load.

One of the substations became overloaded, and a 500-kw. synchronous motor-generator set was purchased to replace the 200-kw. rotary converter formerly installed. This was an 80 per cent power-factor motor and was connected to the power-house bus by a line about a mile long, this line supplying the motor-generator set only.

DATA ON PLANT OPERATION

Synchronous motor	Not Running		Running	
Date	September 13, 1922		February 13, 1923	
Time	10:00-10:30 A.M.	10:35-11:05 A.M.	8:19-8:49 A.M.	9:09-9:39 A.M.
A.-c. line voltage	2,295	2,287	2,330	2,331
Total amperes	474	466	498	549
Total kilowatts	1,412	1,336	1,901	1,993
Power-factor indicator	0.75	0.74	0.93	0.91
Power factor (calculated)	0.75	0.72	0.95	0.90
Frequency indicator	60.4	60.6	61.2	61.0
Exciter voltage	130	131	114	120
No. 1 Engine				
Wattmeter	285	275	467	451
A.-c. ammeter	130	123	133	147
Field ammeter	159	154	147	157
Power factor (calculated)	0.55	0.56	0.87	0.76
Field excitation, kilowatts	20.7	20.2	16.8	18.8
Field excitation per cent	7.3	7.4	3.6	4.2
No. 2 Engine				
Wattmeter	280	274	459	465
A.-c. ammeter	131	127	140	147
Field ammeter	161	159	151	160
Power factor (calculated)	0.54	0.54	0.81	0.78
Field excitation, kilowatts	20.9	20.8	17.3	19.2
Field excitation per cent	7.5	7.6	3.8	4.1
No. 1 Turbine				
Wattmeter	847	787	975	1,077
A.-c. ammeter	236	215	244	272
Field ammeter	119	116	106	109
Power factor (calculated)	0.90	0.92	0.99	0.98
Field excitation, kilowatts	15.5	15.2	12.1	13.1
Field excitation per cent	1.8	1.9	1.2	1.2

Next time the 2,500-kw. turbine required overhauling it was found not necessary to shut down part of the equipment as formerly and work part of the miners night shift, for the whole load was carried satisfactorily on the small units. Readings were taken during the peak load of this period and are given in the two right-hand columns of the table. From the table it will be seen that not only was the load carried by the engines increased approximately 70 per cent over its former value, but the power factor of the individual engine generators was increased in even greater ratio than the power factor of the whole system. As this shut-down of the 2,500-kw. turbine was due to a burned-out armature which required about two weeks to repair and as there was an urgent demand for every ton of

THE DETROIT EDISON CO. LIBRARY DEC 7 1923

coal that could be mined, it can safely be said that the investment in the synchronous-motor generator set proved to be a profitable one. There was also a considerable saving in the percentage of energy required for excitation.

In another case, a paper mill having a 1,000-kw. 80 per cent power-factor and a 1,250-kw. 80 per cent power-factor turbo-generator, was obliged to run the latter continuously; owing to a power factor of 68 to 70 per cent the current at 800 to 850 kw. exceeded the safe current for the 1,000-kw. machine. By installing a 200-hp. synchronous motor, which made possible raising the power factor to 88 per cent, the current was reduced below the capacity of the 1,000-kw. turbine and one machine was again available as a spare. In this way, by a comparatively small expenditure for synchronous-motor equipment, it is sometimes possible to change the power factor sufficiently to operate satisfactorily with apparatus that would otherwise be unable to do the work or to provide adequate spares at an expense negligible compared with new equipment. The examples of this given in the foregoing are only two of the many cases where power-factor correction has demonstrated its sound economic value, but there still remains much to be done. H. D. FISHER.

New Haven, Conn.

Why Not Ask the Manufacturer?

I read with a great deal of interest the article by Mr. Annis on "Characteristic Curves of Centrifugal Pumps," in the Oct. 23 issue, and I feel sure it will prove of much value to many readers of *Power* who operate pumps of this type or who may have occasion to order one for a special service. Mr. Annis has pointed out very clearly by means of diagram that, unlike the duplex pump, a centrifugal pump of one type is not adapted to all classes of service and before ordering one it would be advisable to place before the manufacturer all the particulars or details of the service for which the pump is required. In this way a pump having the proper characteristic and the best efficiency is obtained.

Unfortunately, many engineers do not consider it necessary to ask the manufacturers' advice in any particular, with the result that many times equipment is bought and installed only to discover that it is not suitable for the service for which it was intended.

A case of this kind came to my attention not long ago in a plant containing four 3,500-sq.ft. water-tube boilers. The superintendent thought he would improve the economy of his plant by providing for a more uniform water level in the boilers. Accordingly, he ordered four feed-water regulators and had them installed on the boilers without giving any thought as to how it would affect the operation of the feed pump, which was controlled from a float in the heater. When the regulators were put in service, it was immediately apparent that they were of little value without a new control on the pump. As long as all four boilers were in service, little trouble was experienced, but during light-load periods, when only one boiler was operating and the feed valves to the other boilers were closed, a slight increase in the amount of water fed to the boiler caused the regulator to close the valve, thus shutting the discharge of the pump entirely and causing an excessive pressure to be built up in the discharge line.

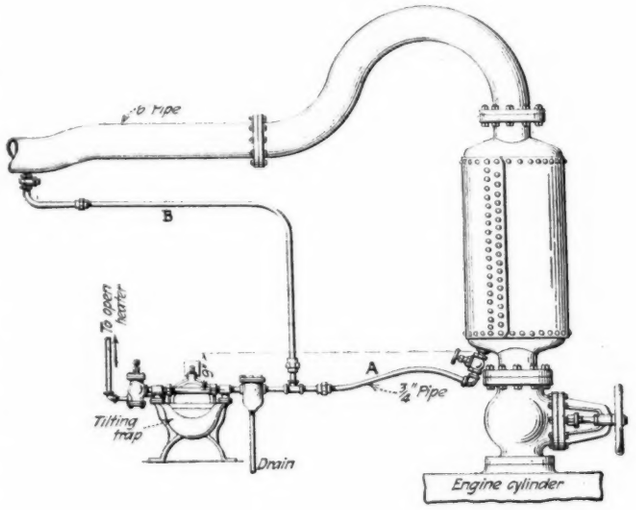
After the regulators had been in use about three weeks, they were cut out of service and have not been used since, and the water level is once more taken care of by hand regulation of the feed valves.

Many other cases of this kind might be cited, and all tend to demonstrate the fact that engineers who are not experienced with certain types of equipment should obtain some advice before spending on unsatisfactory equipment, appropriations that could be used to much better advantage if a little forethought were used.

Memphis, Tenn. E. C. THOMAS.

Will Changing the Connections to the Trap Improve Its Operation?

I read with special interest the article on "Steam Trap Installation and Operation," by Mr. Robertson, in the Oct. 9 issue. In the plant where I took charge recently there is a trap that gives unsatisfactory service



HOW TRAP IS CONNECTED TO SEPARATOR AND STEAM MAIN

due to operation. It is connected to a separator directly above the engine cylinder, as shown in the illustration. The inlet of the trap is about 9 in. below the bottom of the separator; there is also a drain from the main steam pipe connected just ahead of the trap inlet as shown. I have had the discharge valve refaced, and have put the trap in good condition, but still it does not work satisfactorily. There is, of course, not much condensation, the separator being only 50 ft. from the boilers. The main steam line and separator are well insulated, so the trap is required to discharge only at fairly long intervals.

In my opinion the trap should be placed two or three feet below the outlet from the separator. Also, I think that the connection *B* interferes with the filling of the trap. Upon making inquiries when I first came to the plant, I was informed that this connection was put in, not for draining the steam main at that point, but to empty the trap with the live steam of the main.

I would be glad to hear from some reader of *Power* as to what changes might be made to insure satisfactory operation, and also if a vent connected between the trap and separator, as shown in Fig. 7 of Mr. Robertson's article, would not substantially improve the operation. B. J. VAN KEEHERN.

Medicine Hat, Alberta, Canada.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Rumbling of Safety Valve

What causes a pop safety valve to chatter on its seat with a rumbling noise, and how can this be prevented? R. B.

Chattering or rumbling of a safety valve occurs when the pressure exerted by the escaping steam is just enough to balance the valve, but not enough to hold it clear of its seat. The chattering can be prevented by adjusting the blowdown ring to obtain more blowdown, as blowdown or holding the valve open until the boiler pressure is reduced below the pop pressure is obtained by causing the escaping steam to react in such a manner as to assist the boiler pressure in holding the valve clear of its seat.

Area of Segment of Circle

What is the formula for finding the area of a segment of a circle, in square inches, without having to measure the length of arc or refer to a table of areas of circular segments? A. C. M.

The area of a segment of a circle is given in square inches by the expression

$$\frac{4H^3}{3}\sqrt{\frac{2R}{H}-0.608}$$

where H is the height of the segment in inches, and R is the radius of the arc in inches.

For example, if the height is 14 in. and radius of the arc is 36 in., the area of the segment would be

$$\frac{4\times 14\times 14}{3}\times\sqrt{\frac{2\times 36}{14}-0.608}=556.5\ sq.in.$$

Critical Speed of Steam Turbine

What is the critical speed of a steam turbine? F. B. M.

There are several views of this question. Originally, the critical speed referred to a turbine speed which represented the same number of revolutions per minute as the rotating element would vibrate, due to the load and elasticity, in vibrations per minute. Sometimes there are critical vibrating speeds due to other causes.

The rotating element represents a mass in elastic suspension. The rotor of a horizontal turbine will vibrate up and down in a natural period of its own. In the case of a vertical machine there is also a natural period of vibration in a horizontal direction. If the rotor were deflected a small amount, say ½ in., and then quickly released, it would vibrate for a short period of time in its own natural period of vibration.

When the number of vibrations per minute, which is natural to the rotating element, equals the number of revolutions per minute of the rotor, the turbine is said to be running at its critical speed. High-speed single-stage DeLaval turbines originally had a critical speed of about one-quarter to one-third of the operating speed. This represented an unusually flexible shaft, producing a comparatively slow period of rotor vibration. Multi-stage machines at the present time are in many cases built with a critical speed about three-fourths the operating speed. This represents a comparatively less flexible shaft. On the other hand, some turbines are built with a much more rigid shaft whether they are in single stage or multiple stage, and in this case the critical speed is above the operating speed. Turbo-blowers, operating at approximately 20,000 r.p.m., are sometimes built with very rigid shafts, so that the critical speed is even above this high operating speed. It is perhaps easily seen that out-of-balance conditions or misalignment will more readily produce vibration in the rotor if the turbine is running at its critical speed. In this case the shocks received from the abnormal conditions are likely to correspond to the period of vibration of the rotor.

Long turbine blades have a natural period of vibration of their own, and also disks, in some cases, have a pronounced period of vibration, neither one of these corresponding exactly to the calculated critical rotor speed. It often happens also that flexible structural foundations, such as steel platforms, have pronounced periods of sympathetic vibration. Also, supports for the bearings have a natural period of their own, which may be such as to pick up vibrations from the turbine. It is not necessary that such parts shall naturally vibrate absolutely at the running speed. If they vibrate at one-half or sometimes at two-thirds the running speed, they may vibrate sympathetically.

A critical speed, or vibrating speed, may therefore be produced by vibration of disks, blades, foundations or other elements. However, speeds that produce such vibration usually are not spoken of as the critical speeds, as the term refers to the calculated period of vibration of the rotor due to the mass in flexible suspension.

When a turbine is brought up to speed, it frequently happens that at some particular speed a slight vibration is noticed. This does not necessarily represent the calculated critical speed. It may be due to sympathetic condition of disk blades or other elements. Quite often, heavy pressed or shrunk disks along the shafts or rotor may tend to bind the rotating elements somewhat unevenly. In heating up the rotor and bringing the machine to speed, other unbalanced stresses may be introduced that are responsible for the apparent critical speed, and these apparent critical speeds usually are absent or very much less when the turbine is being shut down.

Easy Lessons in Engineering

Extreme Accuracy With a Slide Rule

The probable error of a single operation on a 10-in. slide rule is about one part in a thousand (or 0.1 per cent) with the lower scale, and one part in five hundred (or 0.2 per cent) with the upper scale. Where several operations are carried out in succession the per cent error increases somewhat, although not generally in proportion to the number of operations, because not all the errors are in the same direction.

Longer slide rules are correspondingly more accurate, the error with a 20-in. rule being about half that with a 10-in. rule. Assume that the operation considered is a single multiplication or division performed on the lower scale of a 10-in. rule. Then if the operator has reasonable skill, the third significant digit will never differ by more than 1 from the correct figure. Significant figures begin with the first figure that is not a zero. For example, in the number 0.06032, the first significant figure is 6, the second is 0, the third is 3, and the fourth is 2. The same holds for 60.32 and for 0.006032.

Assuming that the error is exactly 0.1 per cent, the error in the fourth significant figure will be about 1 if the first significant figure is 1, as in 0.01362. It will be about 2 if the first significant figure is 2, and so on. For this reason it is usually worth while writing down the fourth significant figure as closely as it can be read, when the first is 5 or less. Where the first significant figure is above 5, three significant figures are all that have much meaning.

This degree of accuracy is sufficient for the great majority of problems that occur in power-plant engineering. It occasionally happens, however, that greater precision is required. This is the case where figuring two values of about the same size to get their difference. In such a case a small per cent error in the large numbers may result in a large per cent error in their difference. To avoid this large error, it is customary to make the original multiplication or division long hand to obtain answers correct to four or five or more significant figures. Much of this labor can be avoided by the intelligent use of a slide rule in connection with long-hand computations.

In the examples to be considered we will assume that an error of 1 in the last significant figure is permissible. Then the slide rule may be used for the last three significant figures and long-hand computations for those before. Consider first an example in multiplication, as follows: $2.7946 \times 1.73.25 = ?$ to five significant figures. By straight long-hand computation the solution would be:

$$2.7996 \times 173.25 = 484.164450$$

The second number can be split into two parts, 170 and 3.25, using the first for long-hand computation and the second for slide rule.

By the combination method the problem would be solved as follows:

Long-hand operation	Slide-rule operation
2.7946	$2.7946 \times 3.25 = 9.08$
170.	
1956220	Combining operation
27946	475.08
475.0820	+9.08
	484.16 Answer

Again take the problem $912.634 \times 35.8729 = ?$ to six significant figures. The solution by the combined method is as follows:

Long-hand operation	Slide-rule operation
912.634	912.634×0.0729
35.8	$= 66.5$
7301072	Combining operation
4563170	32,672.3
2737902	66.5
32,672.2972	32,738.8

Division by this combined method is just as easy. It is only necessary to proceed long hand until there are but three figures left to be obtained in the quotient and then divide the remainder with the slide rule. The following example illustrates division by this method:

293,463 ÷ 141,871 = ? to six places.

141,871)293,463(2.06+
283,742

972100
851226

120874

By slide rule

1,209 ÷ 141,900 = 0.00851
+ 2.06

= 2.06851 Answer

Square roots accurate to five significant figures may be quickly obtained by the following rule:

A Get root to three figures with the slide rule.

B Divide original number long hand by root of *A*, carrying answer to six figures.

C Average the slide-rule root of *A* with the answer of *B*, to get root correct to five figures.

The following example shows the application of this rule:

$\sqrt{243.67} = ?$ to 5 places.
Slide-rule root = 15.6.
243.67 divided (*long hand*) by 15.6 = 15.619.
Average of 15.6 to 15.619 = 15.610.
Check $15.610^2 = 243.67+$.

Standards for Pipe Fittings at Higher Pressures and Temperature

SPECIFICATIONS for flanges and fittings at 750 deg. F. for pressures of 250, 400, 600 and 900 lb. per sq.in. were confirmed Nov. 21 by Sub-Committee No. 3 on the Standardization of Steel Flanges and Flanged Fittings. These are to be passed on to the Sectional Committee of the American Engineering Standards Committee, as explained in the Nov. 13 issue, which meets Dec. 5 (the original tentative date being Dec. 6).

Materials, tests, allowable stresses, normalizing, etc., form a large part of the specifications not here included, but which may be obtained from the sponsor bodies; namely, Heating and Piping Contractors' National Association, Committee of Manufacturers on Standardization of Fittings and Valves, and the A.S.M.E. Engineers' comments are desired before his date if possible.

In working up the dimensions for flanges, it was desired to specify only minimum limits as much as possible, changes in the strengthening direction being optional. Some flanges for the 400-, 600- and 900-lb. sizes were made up according to these specifications and tested. The results demonstrated satisfactorily the truth of the formulas used. The data published are subject to later changes, due to typographical errors, etc. Steel bolts only were considered in these particular flanges, as specified in detail in the materials specifications. Standards for higher pressures and greater pipe sizes are to be worked out in co-ordination with special tests, which will be presented at a later date.

General Notes—American Steel Flanged Standards

1. In accordance with the Resolutions of Nov. 2, the following standards were considered: American 250-lb. W.S.P. Steel Flanged Standard (extra-heavy cast-iron dimensions); American 400-lb. W.S.P. Steel Flanged Standard (extra-heavy cast-iron dimensions with one size larger bolts); American 600-lb. W.S.P. Steel Flanged Standard (800-lb. Hydraulic American Standard); American 900-lb. W.S.P. Steel Flanged Standard (1,200-lb. Hydraulic American Standard).

2. Wherever necessary the bolting was increased so that the stress does not exceed 7,000 lb. per sq.in. considering the pressure as acting on the area of the O.D. of raised face, and 14,000 lb. per sq.in. for the small tongue in the following formula:

$$S = \frac{PA + 12\,PB}{C}$$

in which

S = Stress in the bolts, lb. per sq.in.;
A = Area of the inside of tongue, sq.in.;
B = Area of the tongue, sq.in.;
C = Effective area of the bolt metal, sq.in.;
P = Steam pressure, lb. per sq.in.

3. The above stresses were considered satisfactory for ordinary bolt material having a minimum tensile strength of 60,000 lb. per sq.in. and a minimum yield point of 30,000 lb. per sq.in. However, alloy steel studs with two nuts having a minimum of 8 threads per inch are recommended for superheated steam service.

4. Due to the increased bolting, on some sizes it was necessary to increase the bolt circle, flange diameter and center-to-face dimensions. Such changes are explained for each standard.

Explanatory Notes—Flange Facings for All Pressures, Table II

1. The outside diameter of raised face, vanstone, large male and large tongue is the same, being the minimum diameter considered practical for vanstone joints.

2. The outside diameter of the small male was made equal to the root diameter of a straight male locknut thread and is especially designed for use with the American 1,200-lb. W.S.P. Steel Flanged Standard and the small sizes of the other standards.

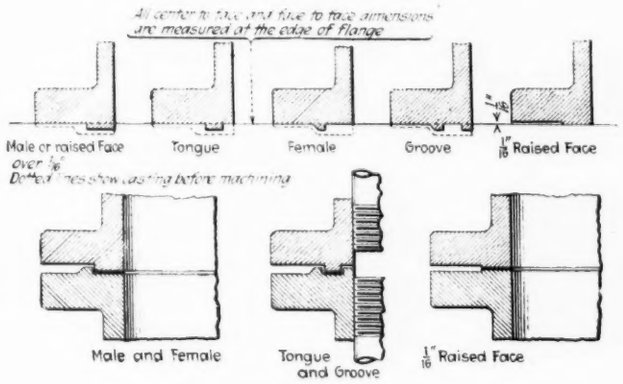
3. The inside diameter of the large and small tongue is the same, the width of the large tongue being twice the width of the small tongue for all sizes except ½-in. to 1¼-in. inclusive where they approach the same width. The large tongue is especially designed for low gasket pressures, the small tongue and groove for high gasket pressures.

4. The diameters of female and groove should be made $\frac{1}{16}$ in. larger or smaller than the corresponding diameters of male and tongue, depending on whether it is an O.D. or an I.D. dimension.

5. All center-to-face and face-to-face dimensions will be given to the edge of the flange, a $\frac{1}{16}$-in. raised face may be cut out of the flange thickness given. For male or raised face over $\frac{1}{16}$-in., tongue, female, and groove, sufficient metal should be added to the face of the flange as shown in figure. In no case should the female or groove be cut out of the flange thickness given.

American 250- and 400-Lb. W.S.P. Steel Flange Standards, Table I

1. The dimensions for 250-lb. are the same as the extra-heavy cast-iron standard with the following exceptions:
   a. The inside diameter of fitting for sizes 14- to 16-in. O.D. inclusive is ¾ in. less than nominal and for the larger sizes 1 in. less than nominal to 20-in. which is 1¾ in. less, 22-in. 1¼ in. less and 24-in. 1⅜ in. less.



TYPES OF FLANGE FACINGS

2. The dimensions for 400-lb. are the same as the extra-heavy cast-iron standard with the following exceptions:
   a. One size larger bolts are used on all but the 15-in. O.D. size, which was kept the same.
   b. The inside diameter of fitting for sizes 14- to 16-in. O.D. inclusive is ¾ in. less than nominal and for 20-in. 1¾ in., for 22-in. 1¼ in., for 24-in. 1⅜ in. less to match tubing.
   c. The center-to-face dimensions are longer than the extra-heavy cast-iron standard to make room for the larger nuts. The face-to-face of reducers are at least equal to the center-to-face of a tee.
   d. Sizes 3½-in. and smaller are the same as the 600-lb. standard for these sizes.
   e. The flange thickness has been increased to take care of the heavier bolts.

American 600-Lb. W.S.P. Steel Flanged Standard, Table I

1. The revised 800-lb. Hydraulic American Standard dimensions were maintained with the following exceptions:
   a. The inside diameter of fitting was made the same as the inside diameter of seamless drawn tubing to the next largest sixteenth.
   b. The size of bolt was increased on the ½-, ⅝-, 1-, 1¼-, 1½-, 4½-, 7-, 18-, 20-, 22- and 24-in. sizes. The diam-

TABLE I—TENTATIVE STEEL-FLANGE STANDARDS

American 250-*Lb. W.S.P.*

Nominal Pipe Size	I. D. of Fittings	Minimum Metal Thickness of Fitting	Number of Bolts	Size of Bolt	Bolt Circle	O. D. of Flange	Minimum Thickness of Flange	C. to F. of Elbow Tee and Cross	C. to F. of 45 Deg. Ell	Long C. to F. of Lateral	Short C. to F. of Lateral	F. to F. of Reducer
			For these sizes use Am. 600 Lb. W.S.P. Steel Flgd. Std.									
1	1	3/8	4	1/2	3 1/2	4 1/2	1 1/16	4	2	6 1/2	2	4 1/2
1 1/4	1 1/4	3/8	4	1/2	3 1/2	5	1 1/16	4 1/2	2 1/2	7 1/4	2 1/4	4 1/2
1 1/2	1 1/2	3/8	4	1/2	4 1/2	6	1 1/16	4 1/2	2 1/2	8 1/2	2 1/2	4 1/2
2	2	7/16	4	5/8	5	6 1/2	1 3/16	5	3	9	2 1/2	5
2 1/2	2 1/2	7/16	4	5/8	5 1/2	7	1	5 1/2	3 1/2	10 1/2	2 1/2	5 1/2
3	3	7/16	8	5/8	6 1/2	8 1/2	1 1/4	6	3 1/2	11	3	6
3 1/2	3 1/2	7/16	8	5/8	7 1/2	9	1 5/16	6 1/2	4	12 1/2	3	6 1/2
4	4	7/16	8	5/8	7 1/2	10	1 3/8	7	4 1/2	13 1/2	3	7
4 1/2	4 1/2	7/16	8	5/8	8 1/2	10 1/2	1 7/16	7 1/2	4 1/2	14 1/2	3 1/2	7 1/2
5	5	7/16	8	5/8	9 1/2	11	1 1/2	8	5	15	3 1/2	8
6	6	1/2	12	5/8	10 1/2	12 1/2	1 5/8	8 1/2	5 1/2	17 1/2	4	9
7	7	1/2	12	5/8	11 1/2	14	1 3/4	9	6	19	4 1/2	10
8	8	1/2	12	5/8	13	15	1 7/8	10	6	20 1/2	5	11
9	9	1/2	12	1	14	16 1/2	1 7/8	10 1/2	6 1/2	22 1/2	5	11 1/2
10	10	9/16	16	1	15 1/2	17 1/2	1 7/8	11	7	24	5 1/2	12
12	12	9/16	16	1 1/4	17 1/2	20 1/2	2	13	8	27 1/2	6	14
14 O.D.	13 1/4	5/8	20	1 1/4	20 1/4	23	2 1/8	15	8 1/2	31	6 1/2	16
15 O.D.	14 1/4	5/8	20	1 1/4	21 1/2	24 1/2	2 3/16	15 1/2	9	33	6 1/2	17
16 O.D.	15 1/4	5/8	20	1 1/4	22 1/2	25 1/2	2 1/4	16 1/2	9 1/2	34 1/2	7 1/2	18
17 O.D.¶												
18 O.D.	17	5/8	24	1 1/4	24 1/2	28	2 3/8	18	10	37 1/2	8	19
20 O.D.	19	11/16	24	1 1/2	27	30 1/2	2 1/2	19 1/2	10 1/2	40 1/2	8 1/2	20
22 O.D.	21	11/16	24	1 1/2	29 1/2	33	2 5/8	20 1/2	11	43 1/2	9 1/2	22
24 O.D.	23	11/16	24	1 1/2	32	36	2 3/4	22 1/2	12	47 1/2	10	24

American 400-*Lb. W.S.P.*

1/4	1/4	3/8	4	1/2	2 1/2	3 1/2	5/8	3	1 1/2	5 1/2	1 1/4	4 1/2
3/8	3/8	3/8	4	1/2	3 1/2	4 1/2	3/4	3 1/2	2	5 1/2	1 1/4	4 1/2
1	1	3/8	4	1/2	3 1/2	4 1/2	1 1/16	4	2	6 1/2	2	4 1/2
1 1/4	1 1/4	3/8	4	1/2	3 1/2	5 1/2	1 1/16	4 1/2	2 1/2	7 1/4	2 1/4	4 1/2
1 1/2	1 1/2	3/8	4	1/2	4 1/2	6 1/2	1 1/16	4 1/2	2 1/2	8 1/2	2 1/2	4 1/2
2	2	7/16	8	5/8	5	6 1/2	1	5 1/2	4	10 1/2	3 1/2	5 1/2
2 1/2	2 1/2	7/16	8	5/8	5 1/2	7 1/2	1 1/8	6 1/2	4 1/2	12 1/2	3 1/2	6 1/2
3	3	7/16	8	5/8	6 1/2	8 1/2	1 1/4	6 1/2	4 1/2	13 1/2	3 1/2	6 1/2
3 1/2	3 1/2	7/16	8	5/8	7 1/2	9	1 5/16	7 1/2	5 1/2	14 1/2	4 1/2	7 1/2
4	4	7/16	8	5/8	7 1/2	10	1 3/8	7 1/2	5 1/2	15	4 1/2	7 1/2
4 1/2	4 1/2	7/16	8	5/8	8 1/2	10 1/2	1 7/16	8 1/2	5 1/2	16	4 1/2	8 1/2
5	5	7/16	8	5/8	9 1/2	11	1 1/2	8 1/2	5 1/2	16 1/2	4 1/2	8 1/2
6	6	1/2	12	5/8	10 1/2	12 1/2	1 5/8	9 1/2	6 1/2	17 1/2	5	9 1/2
7	7	1/2	12	1	11 1/2	14	1 3/4	10 1/2	6 1/2	20 1/2	5 1/2	10 1/2
8	8	1/2	12	1	13	15	1 7/8	11 1/2	6 1/2	22	5 1/2	11 1/2
9	9	1/2	12	1 1/4	14	16 1/2	2	12 1/2	7	24	5 1/2	12 1/2
10	10	9/16	16	1 1/4	15 1/2	17 1/2	2 1/8	13	7 1/2	25 1/2	6	13
12	12	9/16	16	1 1/4	17 1/2	20 1/2	2 1/4	14 1/2	8 1/2	29 1/2	6 1/2	14 1/2
14 O.D.	13 1/4	5/8	20	1 1/4	20 1/4	23	2 1/2	16	9	32 1/2	6 1/2	16
15 O.D.	14 1/4	5/8	20	1 1/4	21 1/2	24 1/2	2 5/8	16 1/2	9 1/2	34	6 1/2	17
16 O.D.	15	5/8	20	1 1/4	22 1/2	25 1/2	2 3/4	17 1/2	10	36	7 1/2	18
17 O.D.												
18 O.D.	17	11/16	24	1 1/2	24 1/2	28	2 7/8	19	10 1/2	39	8 1/2	19 1/2
20 O.D.	18 1/2	11/16	24	1 1/2	27	30 1/2	3	20 1/2	11	42 1/2	8 1/2	20 1/2
22 O.D.	20 1/2	11/16	24	1 1/2	29 1/2	33	3 1/4	22	11 1/2	46	9 1/2	22
24 O.D.	22 1/2	11/16	24	1 1/2	32	36	3	24	12 1/2	50	10 1/2	24

American 600-*Lb. W.S.P.*

1/4	1/4	3/8	4	1/2	2 1/2	3 1/2	5/8	3	1 1/2	5 1/2	1 1/4	4 1/2
3/8	3/8	3/8	4	1/2	3 1/2	4 1/2	3/4	3 1/2	2	5 1/2	1 1/4	4 1/2
1	1	3/8	4	1/2	3 1/2	4 1/2	1 1/16	4	2	6 1/2	2	4 1/2
1 1/4	1 1/4	3/8	4	1/2	3 1/2	5 1/2	1 1/16	4 1/2	2 1/2	7 1/4	2 1/4	4 1/2
1 1/2	1 1/2	3/8	4	1/2	4 1/2	6 1/2	1 1/16	4 1/2	2 1/2	8 1/2	2 1/2	4 1/2
2	2	7/16	8	5/8	5	6 1/2	1	5 1/2	4	10 1/2	3 1/2	5 1/2
2 1/2	2 1/2	7/16	8	5/8	5 1/2	7 1/2	1 1/8	6 1/2	4 1/2	12 1/2	3 1/2	6 1/2
3	3	7/16	8	5/8	6 1/2	8 1/2	1 1/4	6 1/2	4 1/2	13 1/2	3 1/2	6 1/2
3 1/2	3 1/2	7/16	8	5/8	7 1/2	9	1 5/16	7 1/2	5 1/2	14 1/2	4 1/2	7 1/2
4	4	7/16	8	5/8	8 1/2	10 1/2	1 3/8	8 1/2	5 1/2	16 1/2	4 1/2	8 1/2
4 1/2	4 1/2	7/16	8	1	9 1/2	11 1/2	1 7/16	8 1/2	6 1/2	17 1/2	5 1/2	8 1/2
5	5	7/16	8	1	10 1/2	13	1 1/2	9 1/2	6 1/2	19 1/2	5 1/2	9 1/2
6	6	1/2	12	1	11 1/2	14	1 5/8	10 1/2	7 1/2	20 1/2	6 1/2	10 1/2
7	6 1/2	1/2	12	1 1/4	12 1/2	15	2 1/16	11 1/2	7 1/2	22 1/2	6 1/2	11 1/2
8	7 1/2	1/2	12	1 1/4	13 1/2	16 1/2	2 1/16	12 1/2	8 1/2	24 1/2	6 1/2	12 1/2
9	8 1/2	1/2	16	1 1/4	15 1/2	18 1/2	2 1/8	14 1/2	8 1/2	27 1/2	7 1/2	14 1/2
10	9 1/2	1/2	16	1 1/4	17	20	2 1/8	15 1/2	9 1/2	29 1/2	7 1/2	15 1/2
12	11 1/2	1	20	1 1/4	19 1/2	22	2 1/2	16 1/2	9 1/2	31 1/2	8 1/2	16 1/2
14 O.D.	12 1/2	1 1/8	20	1 1/2	20 1/2	23 1/2	2 1/2	17 1/2	10 1/2	34	8 1/2	17 1/2
15 O.D.	13 1/2	1 1/16	20	1 1/2	22 1/2	25 1/2	2 1/16	18 1/2	11	36	9 1/2	18 1/2
16 O.D.	14 1/2	1 1/8	20	1 1/2	23 1/2	27	2 1/2	19 1/2	11 1/2	38 1/2	9 1/2	19 1/2

American 900-*Lb. W.S.P.*

1	1	1/2	4	5/8	4	5 1/2	1	4 1/2	3 1/2	8 1/2	2 1/2	4 1/2
1 1/4	1 1/4	1/2	4	5/8	4 1/2	6 1/2	1 1/4	4 1/2	3 1/2	9 1/2	2 1/2	4 1/2
1 1/2	1 1/2	1/2	4	5/8	4 1/2	7	1 1/4	5 1/2	4	10 1/2	3 1/2	5 1/2
2	1 13/16	5/8	8	5/8	5 1/2	7 1/2	1 1/4	6 1/2	4 1/2	12 1/2	3 1/2	6 1/2
2 1/2	2 1/2	5/8	8	5/8	6 1/2	8 1/2	1 1/4	6 1/2	4 1/2	13 1/2	3 1/2	6 1/2
3	2 15/16	5/8	8	5/8	7	9 1/2	1 1/2	7 1/2	5 1/2	14 1/2	4 1/2	7 1/2
3 1/2	3 1/2	5/8	8	1	8 1/2	10 1/2	1 5/8	8 1/2	5 1/2	16 1/2	4 1/2	8 1/2
4	3 15/16	5/8	8	1	9 1/2	11 1/2	1 3/4	8 1/2	6 1/2	17 1/2	5 1/2	8 1/2
4 1/2	4 1/2	5/8	8	1	10 1/2	13	1 7/8	9 1/2	6 1/2	19 1/2	5 1/2	9 1/2
5	4 1/2	5/8	8	1 1/4	11	13 1/2	2	10 1/2	7 1/2	20 1/2	6 1/2	10 1/2
6	5 1/2	11/16	12	1 1/4	12 1/2	15	2 1/16	11 1/2	7 1/2	22 1/2	6 1/2	11 1/2
7	6 1/2	11/16	12	1 1/4	13 1/2	16 1/2	2 1/8	12 1/2	8 1/2	24 1/2	6 1/2	12 1/2
8	7 1/16	11/16	12	1 1/4	15 1/2	18 1/2	2 1/4	14 1/2	8 1/2	27 1/2	7 1/2	14 1/2
9	8 1/16	11/16	16	1 1/4	17	20	2 1/2	15 1/2	9 1/2	29 1/2	7 1/2	15 1/2
10	9 1/16	11/16	16	1 1/4	18 1/2	21 1/2	2 3/4	16 1/2	9 1/2	31 1/2	8 1/2	16 1/2
12	11 1/2	1 1/16	20	1 1/2	21	24	3	17 1/2	10 1/2	34 1/2	8 1/2	17 1/2
14 O.D.	13 1/2	1 1/16	20	1 1/2	22	25 1/2	3 1/16	18 1/2	11 1/2	36 1/2	9 1/2	18 1/2
15 O.D.	13 1/2	1 1/16	20	1 1/2	23 1/2	26 1/2	3 1/16	19 1/2	11 1/2	38 1/2	9 1/2	19 1/2
16 O.D.	14 1/16	1 1/16	20	1 1/2	24 1/2	27 1/2	3 1/4	20 1/2	12 1/2	40 1/2	10 1/2	20 1/2

eters of bolt circle and flange were increased on the small sizes to take care of the larger bolts. The outside diameter of the flange on the large sizes was increased ¼ in. to take care of the larger bolts, the established bolt circle being maintained.

c. The minimum flange thickness was increased on the 1½-in. size, also on 7, 8, 15 and 17.

d. The center-to-face dimensions are the same except height of male has been subtracted from the standard hydraulic dimensions.

e. The face-to-face of reducer is the same as the center-to-face of ells, tees and crosses with a minimum of 4½ inches.

TABLE II FLANGE FACINGS FOR ALL PRESSURES

Nominal Pipe Size	O. D. Raised Face and Van Stone	O. D. of Large Male	O. D. of Small Male	O. D. of Large Tongue	O. D. of Small Tongue	I. D. of Small and Large Tongue	Height of Tongue or Male	Depth of Groove or Female
1	1 3/8	1 3/8	1 3/16	1 3/8	1 3/8	1	3/16	3/16
1 1/4	1 11/16	1 11/16	1 5/16	1 11/16	1 11/16	1 1/4	3/16	3/16
1 1/2	2	2	1 5/16	2	2	1 1/2	3/16	3/16
2	2 3/8	2 3/8	1 13/16	2 3/8	2 3/8	2	3/16	3/16
2 1/2	2 7/8	2 7/8	2 5/16	2 7/8	2 7/8	2 1/2	3/16	3/16
3	3 3/8	3 3/8	2 13/16	3 3/8	3 3/8	3	3/16	3/16
3 1/2	4	4	3 5/16	4	4	3 1/2	3/16	3/16
4	4 5/8	4 5/8	3 13/16	4 5/8	4 5/8	4	3/16	3/16
4 1/2	5 1/8	5 1/8	4 5/16	5 1/8	5 1/8	4 1/2	3/16	3/16
5	5 5/8	5 5/8	4 13/16	5 5/8	5 5/8	5	3/16	3/16
6	6 5/8	6 5/8	5 13/16	6 5/8	6 5/8	6	3/16	3/16
7	7 5/8	7 5/8	6 13/16	7 5/8	7 5/8	7	3/16	3/16
8	8 5/8	8 5/8	7 13/16	8 5/8	8 5/8	8	3/16	3/16
9	9 5/8	9 5/8	8 13/16	9 5/8	9 5/8	9	3/16	3/16
10	10 5/8	10 5/8	9 13/16	10 5/8	10	9 5/8	3/16	3/16
11	11 5/8	11 5/8	10 13/16	11 5/8	11	10 5/8	3/16	3/16
12	12 5/8	12 5/8	11 13/16	12 5/8	12	11 5/8	3/16	3/16
14	15	15	12 5/8	15	14 1/8	13 5/8	3/16	3/16
15	16 1/8	16 1/8	13 5/8	16 1/8	15 1/8	14 5/8	3/16	3/16
16	17 1/8	17 1/8	14 5/8	17 1/8	16 1/8	15 5/8	3/16	3/16
17	18 1/8	18 1/8	15 5/8	18 1/8	17 1/8	16 5/8	3/16	3/16
18	19 1/8	19 1/8	16 5/8	19 1/8	18 1/8	18	3/16	3/16
20	21	21	17 5/8	21	20 1/8	19 1/2	3/16	3/16
22	23	23	19 5/8	23	22	21	3/16	3/16
24	25 1/8	25 1/8	21 5/8	25 1/8	24 1/8	23 1/2	3/16	3/16
26	27 1/8	27 1/8	23 5/8	27 1/8	26 1/8	25 1/2	3/16	3/16

f. The diameter of bolt circle and flange were changed on the ¾-, 2- and 3-in. sizes and are the same as the extra-heavy cast-iron standard dimensions.

American 900-Lb. W.S.P. Steel Flanged Standard, Table I

1. The revised 1,200-lb. Hydraulic American Standard dimensions were maintained with the following exceptions:

a. The ⅛-in. and ¾-in. sizes have been omitted on account of the small core, so whenever these small sizes are required the 1-in. fitting should be bushed down to match the pipe.

b. The inside diameter of fitting sizes 1½-in. and smaller are made to match double-extra-strong pipe and sizes 2-in. and larger seamless drawn tubing.

c. The size of bolt was increased on the 1-, 1¼-, 1½-, 4-, 5-, 15-, 16- and 18-in. sizes, the flange diameter being increased accordingly. The bolt circle was increased only on the 15-in. size.

d. The minimum flange thickness was increased on practically all sizes to agree with calculations.

e. The center-to-face dimensions are the same as the 1,200-lb. Hydraulic American Standard with the ¼-in. male subtracted.

f. The face-to-face of reducer is the same as the center-to-face of ell, tee and cross with 4½ in. as the minimum.

Pipe thicknesses were determined by the latest proposed formula worked out by the subcommittee to the A.S.M.E. Boiler Code Committee on Specifications for Steam Piping.

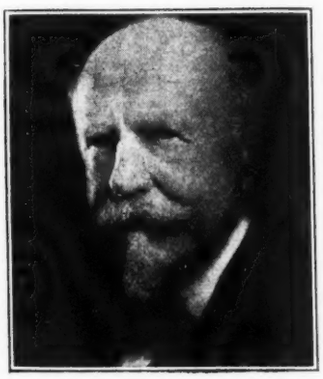
Butt-welded steel pipe was figured for all standards, sizes ½-in. to 2-in. inclusive. Lap-welded steel pipe was figured for the American 250- and 400-lb. W. S. P. Steel Flanged Standards, sizes 2-in. and larger. Seamless drawn tubing was figured for the American 400-, 600-, 900- and 1,350-lb. W.S.P. Steel Flanged Standards, sizes 2-in. and larger. No tubing less than F. W. pipe is used.

News in the Field of Power

J. R. Freeman Recipient of A. S. M. E. Medal for 1923

John Ripley Freeman was recommended to receive the Society Medal for the year 1923 by the A.S.M.E. Committee of Awards and Prizes for his services to engineering and manufacturing by his work in fire prevention and preservation of property.

Mr. Freeman became associated with the Factory Mutual Insurance Companies in 1886, when they were small and their membership was confined mainly to New England factories. One of his earliest activities was the conducting of a series of experiments on



JOHN RIPLEY FREEMAN

fire streams, during which the friction loss of water flowing through various kinds of hose was determined and the most efficient shape for nozzles adopted. The results of these tests, made at Lawrence in 1888, were tabulated and published as Fire Stream Tables. These tables are the standard used by all engineers having to do with the flow of water through nozzles and hydrants. Mr. Freeman made various studies of pumps and developed the design for the Underwriters' steam fire-pump.

Big New Mississippi Plant for Davenport, Iowa

A superpower steam plant costing $10,000,000 and generating eventually at least 200,000 hp., where electricity will not only be manufactured for the consumption of the surrounding industrial community, but will be stepped up to 66,000 volts or 132,000 volts for long-distance transmission, will be built on the banks of the Mississippi River, two miles above Davenport, Iowa, according to an announcement of Vice-President and General Manager B. J. Denman, of the United Light & Railways Co., which, with its headquarters at Grand Rapids, Mich., controls the Tri-City Railways & Light Co., serving Davenport as well as Rock Island and Moline, Ill., and other places.

A. S. M. E. Papers of Interest to Power Plant Men

TUESDAY—"Heat Transfer for Fluids Flowing Inside Pipes," by W. H. McAdams and T. H. Frost; "A Graphical Study of Journal Lubrication," by H. A. S. Howarth; Fluid Meters Session.

Wednesday — "Fundamental Factors in the Spontaneous Combustion of Coal," by O. P. Hood; "Economic Phases of Coal Storage," by F. G. Tryon; "Coal Handling and Coal Storage," by H. E. Birch and H. V. Coes; "A Calorimetric Method of Surveying the Behavior of Steam," by N. S. Osborne; Session on Hydro-Electric Power; "Fundamentals Underlying Hydro-Electric Development," by J. R. Freeman.

Thursday — "Economy Characteristics of Stage Feed-Water Heating by Extraction," by E. H. Brown and M. H. Drewry; "High Pressure, Reheating and Regenerating for Steam Power Plants," by C. F. Hirshfeld; "Reheating in Central Stations," by W. J. Wohlenberg; "The Margins of Possible Improvement in the Central-Station Steam Plant," by E. L. Robinson; "Boiler Test Results with Preheated Air," by C. W. E. Clarke; "Boiler-Plant Economics," by N. E. Funk and F. C. Ralston; "The Solid-Injection Oil Engine," by H. F. Shepherd; "Economic Status of the Oil Engine," by L. H. Morrison; "Salt-Velocity Method of Measuring Water," by C. M. Allen; "Measuring the Flow of Water in Closed Conduits," by N. R. Gibson; "Flow of Water in Short Pipes," by O. W. Boston.

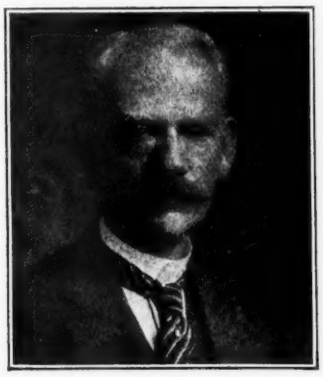
Reorganization of Interior Department To Be Urged

Fearing failure of the Brown Plan of Government Reorganization, devised by the Joint Committee of the House and Senate and sponsored by the late President Harding, engineering and allied bodies numbering more than 200,000 members will conduct a country-wide movement to make over the Department of the Interior. The engineers, it is announced, have definitely decided to press for the adoption of that part of the Brown Plan which affects this department.

F. A. Halsey Awarded A. S. M. E. Medal for 1922

The Committee on Awards and Prizes of the A.S.M.E. recommended that the society medal, for the year 1922, be awarded to F. A. Halsey.

His paper, "Premium System of Wage Payments," was presented before the Society at the Providence meeting in 1891 and the adoption of the methods proposed by him at that time have had a most desirable effect toward harmonizing the relations of worker and employer and are now a recognized factor in factory management. Briefly, the premium system



FREDERICK ARTHUR HALSEY

consists in establishing a standard task to be completed within a given time. When there is any saving in time, this saving is divided between employer and the workman in accordance with some agreed-upon basis, usually an equal division. The result is that the workman receives a greater wage for a given time, while the employer gets the output at a lowered cost.

Survey of Muscle Shoals Is Being Made

A survey of the power market in the region tributary to Muscle Shoals is being made by the federal government. The Department of Commerce, the Ordnance Department and the Federal Power Commission are participating. Apparently, this information is being gathered to enable the government to calculate the value of a lease should it be decided to handle the Muscle Shoals proposition on such a basis.

A bill is to be introduced early in the new Congress to provide that the leasing of power at Muscle Shoals must be conducted under the provisions of the Water Power Act.

New York Barge Canal Water To Be Measured

Measurement of the water passing through the New York Barge Canal is to be undertaken to determine whether or not water in excess of the amount needed for navigation is being diverted from the Niagara River.

It is contended by representatives of the federal government that no water is being diverted through the canal over and above the requirements for navigation, although in issuing a license to the Niagara Falls Power Co. it was assumed that 500 cu.ft.-sec. of treaty water was going through the canal. Certain interests in Lockport and Medina have laid claim to the right to use this 500 cu.ft.-sec. of treaty water and have applied to the Federal Power Commission for a license to cover its use.

Maine Called Upon to Take Action in Power Legislation

A clarion call to the people of Maine to take action to end the present impasse regarding the non-exportation of power from the state and to encourage hydro-electric development for interconnection purposes was sounded by Clarence C. Stetson, of Bangor, Me., Nov. 22, in an address before the Bangor Chamber of Commerce. He said:

A most striking instance of sectionalism and individualism in our State, is found in the retention on our statute books of the law forbidding the transmission or conveyance beyond the confines of the state of electric current generated by water power within the state. The main argument of those favoring this law is that Maine will require soon, by reason of its great and immediate industrial developments, all the power for her own uses, and that by keeping this power from going without the state, industries will be forced to come here.

Labor conditions and cheap power are not in themselves enough to force industrial plants to locate in Maine, the speaker pointed out, and existing power developments are perforce small and relatively uneconomical compared with those which might be developed to conform to superpower and interconnection requirements, with exportation of the surplus power only. He further said:

There are today in Maine 500,000 installed hp. and about 700,000 hp. awaiting development. Assuming an increase of 125,000 hp. needed by Maine up to 1932, there would still be a surplus of 575,000 hp. which could be marketed without jeopardizing the interests of the state for some time to come. The neighboring New England States are in need of power, and Maine cannot afford to remain isolated from the superpower development. There is doubt as to the constitutionality of the present non-exportation law, but capital will not seek investment in Maine water power on the needed scale until some definite and constructive water-power policy is established by the state. Development and exportation of power would mean $100,000,000 of new wealth distributed chiefly among the citizens of Maine, $1,500,000 in new taxes annually distributed in Maine and $12,000,000 in new revenue annually in circulation.

Ruhr Mine Owners Sign French Terms

Back Taxes as well as New Taxes Agreed Upon and System of Licenses To Be Continued

HERR VOGLER, of the Deutsch-Luxemburg coal mines, signed an agreement with the French on Nov. 23 on behalf of Hugo Stinnes, Thyssen, Reusch of the Gutchoffnung Hutte, Hubert of the Bochumer Verein, Fickler of Harpener and himself. The agreement gives the French full power of control over the Ruhr output and insures reparation deliveries in kind.

The mines represented by the German delegates will pay as the tax due for the period of Jan. 1 to Nov. 1 the sum of $15,000,000, or 279,000,000 French francs at the rate of exchange on Nov. 23. In future they will pay a tax of 10 francs per ton on coal sold. They will deliver free to the powers of the Entente 18 per cent of their net production. Stocks accumulated in the Ruhr on Oct. 1 become the property of the allied authorities. The system of export licenses remains in force. Accumulated stocks of steel and iron products can be released only against payment of taxes due and can be exported only in quantities equivalent to the average exports of 1922. Deliveries of byproducts, sulphate of ammonia, benzol, tar, creosote, etc., will be subject to a special agreement. This agreement is for a period of six months or until April 15, 1924.

A number of Ruhr manufacturers have continued the operation of their works during the controversy and have accumulated a considerable stock of machinery now available for export. While no "dumping" is contemplated, there is every expectation that machinery, including Diesel engines, will be laid down at New York much below current American prices.

Diesel Engines for Engineer Corps Dredges

In order to carry on more rapidly and at reduced cost the important work of keeping the channels of our harbors at the required depth, the Corps of Engineers of the United States Army, which is responsible for this service, has designed four Diesel-engined seagoing dredges of a radically new type. Two of these dredges, the "A. Mackenzie" and "W. L. Marshall," have just been launched at the yards of the Sun Shipbuilding and Dry Dock Company, Chester, Pa., and two more, the "Dan C. Kingman" and the "William T. Rossell," will be completed at the same yards in the near future.

These dredges are the first all-electric ships ever built. Electricity is used on them for every possible purpose: for propulsion, for operating all auxiliary machinery, and for cooking, heating, ventilating and lighting. Every movement of each ship is controlled from the pilot house, where the navigating officer personally starts, stops, changes the speed, and reverses the ship without signaling to the engine room.

Sturgeon Pool Hydro-Electric Development Under Way

The Sturgeon Pool Hydro-Electric development is designed to utilize water power from Walkill Creek, a tributary of and flowing into the Hudson River, near Kingston, N. Y. The dam and power house are located at Rifton, N. Y., and the development will ultimately yield 30,000 hp., of which about 18,000 hp. is to be utilized immediately.

The dam is of the gravity type, with 78,000 cu.yd. of concrete construction resting on rock, and is about 700 ft. long, over all, and 112 ft. high. There are six butterfly sluice gates to control the water level in the pool above. Leading from the dam to the power house are four penstocks of 10-ft. diameter each, equipped with a motor-operated Broome gate 11 ft. wide and 13 ft. high.

The present installation in the power house wil consist of three 6,000-hp. units of vertical type.

Girand License Again Before Federal Power Commission

The Governor of Arizona has declined to extend the time of the state license covering the Girand development at Diamond Creek on the Colorado River. Mr. Girand has filed the Governor's letter with the Federal Power Commission.

This puts it squarely up to the Federal Power Commission to take action in this case, which involves a $90,000,000 transaction. Arizona would be the greatest sufferer were the scheme to fall through. For that reason some are of the opinion that the state executive may change his mind once he is sure the Federal Commission will not grant the Girand license before Dec. 26.

There is also the possibility that the copper company might decide to use fuel oil.

On the other hand, the Federal Commission must face a heavy moral, and possibly a legal responsibility, if through failure to grant a license, Mr. Girand, who has complied with all the conditions of the preliminary permit, should be subjected to great losses. Reference frequently has been made to the alleged action of the Federal Power Commission in trying to coerce the sovereign State of Arizona into acceptance of the Colorado River Compact. Some are of the opinion that coercion now is being exerted on the Federal Power Commission by Arizona.

Which Department Should Get the Coal Cost Facts?

Friends of the Federal Trade Commission in Congress are prepared to insist that there should be no repudiation of the Commission in the matter of gathering figures on the cost of producing coal. There are a number of national legislators who are expected to insist upon compulsory returns being made to the Federal Trade Commission. Whether the figures are to be submitted voluntarily or on a compulsory basis, the friends of the Commission feel that they should go to this agency of the Federal Government, since it was the Commission which first embarked on this activity and would be continuing it were it not for the legal technicalities that have been placed in its path by those from whom the returns must come. To allow this function to pass into the hands of the Department of Commerce or any other government agency, in their opinion, would be a sort of repudiation of the Commission, or at least it would be failure to uphold its hands.

There are other members of Congress who fear the coal industry would be dealt with too sympathically were cost figures to be gathered by other departments.

The experience with the railroads has taught many members of Congress that it is one thing to secure returns, but quite another to secure figures that tell the real story. There are many who believe most railroads are earning, in effect, more than is indicated by the bare returns to the Interstate Commerce Commission. If either voluntary or compulsory figures are submitted to the Federal Trade Commission, there is a feeling among some members of the National legislature that they would be interpreted, not so much as the industry would like but in a way best calculated to serve the public interest.

Safety Valve Fails to Work—Boiler Explodes

Another Argument in Favor of Rigid State License and Inspection Laws

ON NOV. 21 a boiler explosion at the Vida Sugar Refinery, Loreauville, La., caused the death of nine persons and the injury of fifteen, of whom five are in a serious condition.

It has been stated that the explosion resulted from the entrance of cold water in an empty boiler hot from recent firing. Recent advices, however, indicate that this time-honored explanation will no more hold in this case than in any other.

Later information is that a battery of five double-riveted lap-seam horizontal-tubular boilers had just been put into service, to handle the new cane crop. One of these showed a leak at the manhole, was pulled out of service and emptied. As soon as a new gasket had been put into place, the boiler was filled with water and the fires rekindled. Excessive pressure was built up, due no doubt to the valve to the steam main being closed and the safety valve being out of commission. The boiler opened up, the heads and tubes being scattered over the place. The explosion caused a displacement of an adjoining boiler which ruptured along a girth seam. Part of this boiler went through the building and destroyed a double-effect vacuum syrup boiler. As the illustration shows, the remaining three were thrown from their brickwork and received minor injuries. That excessive pressure caused the explosion is proved by the flattening of the boiler tubes, indicating that these collapsed before the boiler plate ruptured.

Federal Officials Wish To Participate in Treaty

The Secretary of War has suggested the advisability of permitting representatives of the Corps of Engineers and of the Federal Power Commission to participate in the early discussions of the proposed treaty of New York, New Jersey and Pennsylvania, as to the utilization of the resources of the Delaware River. Since any compact into which these states might enter affects matters within the jurisdiction of those agencies, Secretary Weeks believes it would be well to have the general commission acquainted with the exact jurisdiction of the federal government in connection with the utilization of the Delaware River.

BOILER EXPLOSION AT VIDA SUGAR REFINERY, LOREAUVILLE, LA.

Causes of the Empty Coal Bin Discussed

At the Providence Section of the A. S. M. E. which was held jointly with the Providence Engineering Society on Nov. 20, Col. George H. Webb, Fuel Administrator of Rhode Island, spoke on "The Empty Coal Bin." He described the railroad situation clearly, pointing out that most of the difficulties were outside of the control of the State. Mention was made of the arbitrary methods used by the coal barons in dictating to the small dealer the kind and quality of coal that he might have at their convenience. He spoke of the attitude of Pennsylvania and its influence on the price of coal and stated that these various influences which forced up the price of coal would have to be corrected or the consumer would be forced to find substitutes for anthracite. Rhode Island was fortunate, he said, in having a large supply of graphitic coal under its surface.

Petroleum Institute Program Announced

The American Petroleum Institute will have on its program at its annual meeting at St. Louis, Dec. 11-13, the following papers which will interest readers of *Power*.

"The Utilization of Petroleum Products," by Henry L. Doherty, president of Henry L. Doherty & Co.; "The Use and Value of Oil Under Boilers and in Diesel Engines for Ship Propulsion," speaker to be announced; "The Oil Industry and the Public," Paul Shoup, president, Pacific Oil Co.; "Standardization of Boilers," Committee Report by A. B. Steen, Texas Co.; "What the Oil-Burner and the Oil Industries Can Do for Each Other and for the Public," J. Parker B. Fiske, president, New England Oil Heating Association and Guy I. Sweney, president, Sweney Gasoline & Oil Co.; "The Refiner's Problem in 1923," George N. Moore, president, Western Petroleum Refiners' Association.

Detroit Engineers Honor Dean Cooley

Some 700 guests responded to the invitation of the Detroit Engineering Society, the Detroit Sections of the A.S.C.E., the A. S. M. E., and the A.I.E.E., to join in a testimonial dinner to Mortimer Elwyn Cooley, who is retiring from the presidency of the F.A.S.E. The topics chosen for the toasts, as well as the men who gave them, were indicative of the wide influence and scope of his life activities. Robert F. Thompson, Judge of New York Supreme Court, spoke of him, "At His Boyhood Home"; Ira N. Hollis, President of the Worcester Polytechnic Institute, "As Cadet and Ensign"; Ernest B. Perry, Manager of Industrial Works, Bay City, Mich., "As Professor of Mechanical Engineering"; Hon. Edwin Denby, "In the Service of His Country"; Granger Whitney, farmer and apple grower, Williamsburg, read his original, breezy and nautical rhyme "On the Yosemite"; Marion L. Burton, President of the University of Michigan, spoke of him "As Dean of Engineering and Architecture"; F. Paul Anderson, Dean of Engineering, University of Kentucky, told of him "In the Engineering Profession"; Philip N. Moore, past president of the F.A.E.S., spoke of his work, "In the Federated American Engineering Societies"; Hon. Chase S. Osborn, Ex-Governor of Michigan, told of him, "As a Companion." Perhaps the spirit of the gathering was summed up in the tribute paid by President Burton: "You didn't come here tonight because Dean Cooley is a scholar, or a teacher, or a great engineer, but because he is a human being, and you love him, and he stands as a living illustration of what America means—unstifled individual initiative."

Coming Conventions

American Association for the Advancement of Science. Burton E. Livingston, Smithsonion Institution Bldg., Washington, D. C. Seventy-fifth anniversary meeting at University of Cincinnati, Cincinnati, Ohio, Dec. 27-Jan. 2.

American Engineering Council of the F.A.E.S. L. W. Wallace, 24 Jackson Place, Washington, D. C. Meeting at Washington, D. C., Jan. 10-11.

American Institute of Chemical Engineers. J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y. Winter meeting at the New Willard Hotel, Washington, D. C., Dec. 5-8.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Midwinter convention at Philadelphia, Feb. 4-8.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 18-21.

American Peat Society. J. H. Beattie, U. S. Department of Agriculture, Washington, D. C. Seventeenth Annual Convention, Hotel Washington, Washington, D. C., Dec. 6-8.

American Petroleum Institute. R. L. Walsh, 15 West 44th St., New York City. Fourth annual meeting at Statler Hotel, St. Louis, Mo., Dec. 11-13.

American Society of Heating & Ventilating Engineers. C. W. Obert, 25 West 39th St., New York City. Annual meeting at New York City, Jan. 22-25.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 3-6.

American Society of Refrigerating Engineers, William H. Ross, 35 Warren St., New York City. Nineteenth Annual Convention at Hotel Astor, New York City, Dec. 3-5.

American Society of Safety Engineers. Genevieve S. Wood, 29 West 39th St., New York City. Annual meeting at New York City, Jan. 18.

Engineering Institute of Canada. Fraser S. Keith, 176 Mansfield St., Montreal, Canada. Annual General Meeting at Montreal, Quebec, Jan. 22—Ottawa, Ontario, Jan. 23-24.

Iowa Engineering Society. Blanche Veig, Acting Secretary, 406 Flynn Bldg., Des Moines, Iowa. Annual meeting at Cedar Rapids, Jan. 29-Feb. 1, 1924.

Kansas Engineering Society. C. V. Waddington, Kansas Gas & Electric Co., Wichita, Kans. Convention at Wichita, Kans., Dec. 11-13.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 5707 W. Lake St., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

National Marine Engineers' Beneficial Association. Geo. A. Grubb, 313 Machinists' Bldg., Washington, D. C. Annual Convention at Franklin Square Hotel, Washington, D. C. Jan. 21-26.

Society of Automotive Engineers, Coker F. Clarkson, 29 West 39th St., New York City. Annual meeting at General Motors Bldg., Detroit, Mich., Jan. 22-25.

Chicago A. S. M. E. Favors Increase in Dues

At the Engineers' Club on Tuesday evening, Nov. 20, the Chicago Section of the A. S. M. E. held a dinner meeting to analyze and discuss the finances of the society and means of increasing the income so that the delegate to the annual convention might carry with him the consensus of opinion of the Chicago Section.

From returns of a questionnaire sent out previously and the vote at the meeting, it would appear that the Chicago Section favors a continuance of the progressive policy of the society. The need for additional income was recognized. The possibilities of enlarging the income-producing activities and securing additional funds from endowment or from contributions from manufacturers interested in specific lines of research work were considered, but aggressive action was not favored. It was the general belief that the additional funds needed might better be secured from a moderate increase in dues and that a definite proportion of the increase be allotted to the sections, so that they might carry on more actively.

New Publications

The Kidwell Two-Flow Ring-Circuit Water-Tube Boiler. By Edgar Kidwell, M. E., Ph. D. Published by Kidwell Boiler Co., Milwaukee, Wis., 1923. Brown board, 8x10-in.; 268 pages; 206 figures; 14 tables.

Although in its purpose of promoting the sale of a certain type of boiler, this book is technically a catalog, the nature of the contents must class it as a comprehensive treatise on the principles of boiler design. From start to finish the volume is notably different from the ordinary catalog. An examination of the contents indicates that the author has made good his promise "to elucidate the underlying principles to an extent never before attempted in a trade publication."

The book is divided into five chapters, dealing respectively with the general plan of the book, underlying principles, applications of the principles, evolution of the ring-type boiler, requirements of a perfect boiler, the Kidwell boiler and chimney stacks for water-tube boilers. Particular attention is given

to the problem of boiler circulation, which is treated in an illuminating manner. Many references to engineering books and periodicals increase the value of this volume, which should be in the library of every engineer who is seriously interested in boiler design, construction and operation.

The American Society for Testing Materials, following the custom of the last two years, have published reprints of the complete report of Committee D-2 on Petroleum Products and Lubricants. This reprint includes the 1923 report of the committee and its subcommittees, and all new and revised tentative standards of the committee. Single copies, $1.

Society Affairs

The Cincinnati-Liberty Section No. 15, N. A. S. E., Cincinnati, Ohio, will hear Herman Miller talk on "Air Compressors," at its Dec. 15 meeting.

The Atlanta Section of the A.S.M.E. will hear Nathaniel Pratt, trustee of the Georgia School of Technology, speak at its meeting Dec. 21 on "An Ideal Engineering Education."

Personal Mention

W. W. Nichols, of the Allis-Chalmers Mfg. Co., Milwaukee, Wis., has recently been elected president of the American Manufacturers Export Association.

D. E. Landvoigt, former secretary of the Washington Section of the A.S.M.E., has recently accepted a position as mechanical engineer with the Utica Heater Co., Utica, N. Y.

William Kelly, of Vulcan, Mich., mining engineer and industrialist, has been nominated as president of the American Institute of Mining and Metallurgical Engineers for 1924.

M. J. Costello, of Babcock & Wilcox Co., New York City, is making an extended trip to the Pacific Coast. He will also visit the company offices in various cities of the Southwest, West and Northwest.

H. L. Unland, for thirteen years with the General Electric Co., principally in the power and mining department, is leaving this company to become associated as electrical engineer with the Victor Talking Machine Co. at Camden, N. J.

L. H. Brown has been appointed manager of the transformer division of the new central-station department of the General Electric Co., Schenectady, N. Y. He was one of the company's first transformer specialists and has a wide personal acquaintance in the central-station industry.

Maxwell V. Sauer, formerly in charge of the hydraulic features of the Queenston, Nipigon, Ranney's Falls and High Falls plants for the Hydro-Electric Power Commission of Ontario, has recently been appointed hydraulic engineer of the Canadian Vickers, of Canada, Ltd., with headquarters in Toronto.

Trade Catalogs

Insulation, Heat—Armstrong Cork & Insulation Co., Pittsburgh, Pa. Catalog, "Insulation," covers the subject of the insulation of high-temperature apparatus such as steam mines, ovens and furnaces and is illustrated with pictures of installations.

Valves—The American Schaeffer & Budenberg Corp., Brooklyn, N. Y. Catalog No. 1400 entitled, "American Spring Pop Safety and Relief Valves," for stationary and marine use, is well illustrated and contains many tables of dimensions, capacities, etc.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Nov. 19, 1923	Nov. 26, 1923
Pool 1	New York	$3.25	$3.25
Smokeless	Columbus	2.35	2.25
Clearfield	Boston	2.50	2.50
Somerset	Boston	2.75	2.75
Kanawha	Columbus	2.00	2.00
Hocking	Columbus	2.00	2.00
Pittsburgh No. 8	Cleveland	1.95	2.00
Franklin, Ill	Chicago	2.75	2.50
Central, Ill	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.75	2.75
West Ky.	Louisville	1.85	2.00
S. E. Ky.	Louisville	2.25	2.25
Big Seam	Birmingham	2.15	2.15

New York—Nov. 28, light oil, tank car lots, 28@34 deg. Baumé, 3¾c. per gal., 36@40 deg. 4c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Nov. 20, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.55 per bbl.; 26@28 deg., $1.65; 28@30 deg., $1.75; 32@36 deg., gas oil, 4¼c. per gal.; 36@40 deg., distillate, 4¾c. per gal.

Pittsburgh—Nov. 21 f.o.b. local refinery, 30@34 deg., fuel oil, 5¼c. per gal.; 36@40 deg., fuel oil, 5¾c.; 34 deg., neutral 8c. per gal.

Dallas—Nov. 23, f.o.b. local refinery, 26@30 deg., $1.30 per bbl.

Cincinnati—Nov. 22, tank-car lots, f.o.b. local refinery, 26@30 deg. Baumé, 5c. per gal.; 30@32 deg., 5¼c.; 38@42 deg., distillate, 6½c. per gal.

Philadelphia—Nov. 23, 28@30 deg., $1.57½@1.62 7/10 per bbl.; 18@22 deg., $1.47@1.51 7/10; 13@16 deg., $1.36½@1.40 7/10 per bbl.

Chicago—Nov. 9. 24@26 deg., $1.72 per bbl.; gas oil, 32@36 deg., $1.92 per bbl.

Boston—Nov. 20, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4¼c. per gal.; light oil, 28@32 deg. Baumé, 6¼c. per gal.

New Plant Construction

PROPOSED WORK

Ala., Birmingham—T. H. Molton, 617 Idelwild Circle, plans to build a 10 story, 100 x 190 ft. hotel on 5th Ave. and 21st St. Estimated cost $1,500,000. Engineer or architect not selected.

Ala., Florence—The Office of the United States Engr. is receiving bids for furnishing structural steel for power house at Wilson Dam. Cost will exceed $25,000.

Calif., Bakersfield — The Kern River Water Storage Dist. will acquire existing canals and irrigating facilities and plan to construct dam on Kern River, also canals, and to install pumping plants, etc. Estimated cost $15,000,000. Engineer not selected.

Calif., Hayward — The Natl. Ice & Cold Storage Co., Postal Telegraph Bldg., San Francisco, plans to build an ice and cold storage plant, here. Estimated cost $75,000.

Calif., Los Angeles—The city is having surveys made for the construction of part of a large hydro-electric development project, including dam at Simpson Reservoir to store 50,922 acre ft., 215 ft. high, 2,670 ft. long, 20 ft. wide on top, 180 ft. long on bottom, loose rock and earth fill construction with wasteway; tunnel, 43,022 ft. long, concrete line, 4 x 5 ft. diameter; penstock, 2,450 ft. long, 81 in. diameter on top, 60 in. on bottom; Kings River Power Plant No. 3 to develop 34,023 hp. with impulse water wheels and generators, at fall of 1,497 ft. Estimated cost $7,050,000. Public Service Comn., 207 South Broadway, Los Angeles, Engrs.

Calif., Mare Island—The Bureau of Supplies & Accounts, Navy Dept., Wash., D. C., will receive bids until Dec. 18 for one motor generator and six transformers for Navy Yard, here.

Calif., Porterville—C. M. Jones and W. W. Slayden plans to build a 1½ mi. canal, small rock diversion dam and power house to develop about 182 hp., equipped with turbines or water wheels and generators, to operate under a fall of 67 ft. Estimated cost $15,000.

Calif., San Francisco—Bliss & Faville, Archts., Balboa Bldg., are receiving bids for the construction of an orphanage consisting of eight buildings, including laundry and power house, near Wawona and 28th Aves. for the San Francisco Protestant Orphan Asylum, c/o Archts. Estimated cost $350,000.

Calif., San Francisco—The city and county, Bd. Public Wks., will receive bids until Dec. 19 for furnishing and delivering electric transmission line insulators for Hetch Hetchy power and water supply project. Estimated cost $200,000. M. M. O'Shaughnessy, City Hall, Engr.

Calif., San Francisco—The Little Wonder Mines Co., Inc., 424 Chronicle Bldg., plans to build a canal, 4,400 ft. long, 4 ft. wide; pipe line, 3,700 ft. flume, 310 ft. steel penstock, 8 to 24 in. diameter; power plant with Pelton impulse wheels to develop 332 hp. at a fall of 117 ft. for mining project in Mariposa County. Estimated cost $25,000.

Calif., Smartville—The Excelsior Water & Power Co. plans to build a multiple arch concrete dam on Deer Creek. A penstock and power house will be constructed by the owners' forces.

Calif., Stockton—T. J. Locke, c/o Case & Forslund, Commercial Savings Bldg., is having plans prepared for the installation of two 10 in. centrifugal pumps, operated by two 20 hp., 1,200 r.p.m. 440 volt motors, to replace existing 12 in. pump. R. G. Clifford, 2130 23rd St., Sacramento, Engr.

Conn., Hartford—The High School Comn., Municipal Bldg., plans to build a 3 story high school on New Britain Ave. Estimated cost $1,500,000. Engineer or architect not selected.

Ill., Chicago—H. E. Wallave, Clk. of the Sanitary Dist. of Chicago, 910 South Michigan Ave., received lowest bids for Calumet Intercepting Sewer, Contract 1 and 95th St. pumping station, divisions A, B, C, D, E, F and G, from the T. J. Forscher Contg. Co., 125th St. and Michigan Ave. $969,050.

Division D. from S. D. C. pump plans and $1,039,050 from makers' pump plans. Noted Nov. 13.

Ill., Oak Park—D. Collins, 810 West Madison St., is having plans prepared for the construction of a 5 story, 140 x 155 ft. apartment house, including steam heating system, on Madison St. and Oak Park Ave. Estimated cost $1,000,000. Hall, Lawrence, Rippel & Ratcliffe, 123 West Madison St., Oak Park, Archts.

Ill., Orland—The city is having preliminary plans prepared for the construction of a waterworks pumping plans, tower, distribution mains, etc. Estimated cost $25,000. E. Hancock, 2047 Ogden Ave., Chicago, Engr.

Ind., Crown Point—The County Comrs. will receive bids until Dec. 17 for the construction of a tuberculosis hospital consisting of six units, to include 2 story, 34 x 525 ft. and 50 x 100 ft. buildings, children's and negro patients' buildings, also a 1 story power plant and garage. Estimated cost $350,000. K. D. Norris, Calumet Bldg., East Chicago, Archt.

Ind., Farmersburg—The Common Council plans the construction of a new waterworks system with electrically operated pumps, etc. Estimated cost $40,000.

Ia., Washington—The city, S. J. Kellogg, Clk., will receive bids until Dec. 14 (change of date), for the construction of waterworks improvements, including building, electrically driven pumps, piping, equipment and a 200,000 gal. elevated tank. A. L. Mullergren, 555 Gates Bldg., Kansas City, Mo., Engr. Noted Nov. 27.

Ky., Elizabethtown—The Mayor and City Council will receive bids until Dec. 17 for waterworks improvements, including the construction of a 750,000 gal. gravity type filtration plant in two units; furnishing four centrifugal pumps and electric motors. B. H. Klyce, 720 4th and 1st Natl. Bank Bldg., Nashville, Tenn., Engr.

Md., Ameelle (Cumberland P. O.)—The Amer. Cellulose & Chemical Co., Ltd., 15 East 26th St., New York, is having plans prepared for the construction of an addition to its plant, here. Estimated cost $500,000. Private plans. The owner is in the market for condensers, filter presses, refrigerating machinery, tanks, containers, electric power and pumping machinery, engines, etc.

Mass., Taunton—The city will receive bids about Dec. 6 for equipment and for the construction of a 3,750 hp. 2,300 volt, power plant, including two 15 x 18 ft. and 30 x 50 ft. buildings and a distributing structure. Estimated cost $225,000. Jackson & Moreland, 387 Washington St., Boston, Engrs. Noted Sept. 11.

Mich., Menominee—The city, H. W. Blandin, Clk., will receive bids until Dec. 11 for installing (1) one centrifugal pump, 2,500 g.p.m., connected to electric motor; (2) two centrifugal pumps, 1,000 g.p.m.; (3) one 6 cycle generator direct connected to gasoline motor; (4) switchboards for pumps and generator. Estimated cost $25,000. B. T. Gifford, Gay Bldg., Madison, Engr.

Mo., Bolivar—The city voted $50,000 bonds for the construction of an electric power plant and distribution system, including two direct connected oil engines, poles, wire, ten transformers, two motor driven centrifugal fire pumps, remote control electrically operated hydraulic valve at standpipe, etc. F. W. Graham, 5244A Cote Brilliante, St. Louis, Engr. Noted May 29.

Mo., St. Louis—The Morse Eng. Co., 1626 Chemical Bldg., A. Morse, Purch. Agt., is in the market for a 60 hp. and 100 hp. Diesel Engine, also a 50 hp. and 75 hp. alternator.

N. J., Maple Shade—The city is having plans prepared for a waterworks and gravity sand filter plant, also aerator, setling basin and four triplex pumps. Estimated cost $50,000. Remington & Voxbury, Courthouse Sq. Bldg., Camden, Engrs.

N. M., Las Cruces—The Elephant Butte Irrigation Dist. of New Mexico, H. H. Brook, Pres., plans to build an 18,000 kw. plant at the Elephant Butte Dam, also an auxiliary dam twenty miles south, to catch the water discharge for power during the winter in excess of the irrigation demand. A secondary plant may be built. Estimated cost slightly less than $5,000,000.

N. Y., Ballston Spa—The Saratoga County Paper Co., Inc., F. J. Talbot, Treas., is in the market for one 3 hp., 1,800 r.p.m., 60 cycle, 220 volt squirrel cage motor with rails and pulley.

N. Y., Brooklyn—The city, Borough Hall, had plans prepared for the construction of an 11 story municipal building on Court and Joralemon Sts. Estimated cost $5,800,000. McKenzie, Voorhies & Gmelin, 342 Madison Ave., New York, Archts. Equipment detail not reported.

N. Y., New York—N. C. Partos, c/o L. A. Abramson, Engr. and Archt., 46 West 46th St., is having plans prepared for the construction of an 18 story, 100 x 100 ft. apartment house on 8th Ave. and 45th St. Estimated cost $2,000,000. Equipment detail not reported.

N. Y., New York — Springsteen & Goldhammer, Engrs. and Archts., 32 Union Sq., are preparing plans for the construction of a 175 x 370 ft. apartment house on 189th St. and Amsterdam Ave. Estimated cost $1,500,000. Owner's name withheld. Equipment detail not reported.

N. C., Chimney Rock — The Chimney Rock Mountains, Inc., L. B. Morse, Pres., plans a summer resort, including the construction of two hotels, club house, large lake, concrete dam, 100 ft. high, etc., also waterworks, sewer and power development for lighting. Estimated cost $4,000,000.

N. C., Hazlewood—The Unagusta Mfg. Co. is in the market for two 150 hp. horizontal return tubular boilers.

N. C., Lake Junaluska—The Southern Assembly is having plans prepared and will receive bids soon after the first of the year for the construction of 1¼ mi. trunk sewer and 4 mi. water main, also for the installation of turbines and generators under dam to generate power for Assembly grounds. Estimated cost $25,000. J. W. Seaver, Engr.

N. C., Mebane—The White Furniture Co. plans to install a new direct or alternating unit about 300 hp; water tube or return tubular boilers, 400 hp., also motors.

Ohio, Barberton—The City Council approved $779,686.50 bonds for the construction of a reservoir to cover about 600 acres, 600,000,000 gal. capacity, capable of providing the city with 8,000,000 g.p.d.; also a dam, 400 ft. long, 200 ft. wide and 30 ft. high with spillway 150 ft. wide to provide against floods. The water will be pumped from the reservoir up 33 ft. into a standpipe, 60 ft. diameter, 1,000,000 gal. capacity, then by gravity pressure from this to the city mains. Estimated cost $1,000,000. W. G. Clark, Engr.

Ohio, Fostoria—The city has had plans prepared and will receive bids soon after Jan. 1 for furnishing and installing two 150 hp. horizontal return tubular boilers and a 3,000,000 g.p.d. crank flywheel pumping engine, etc. Estimated cost $50,000. G. Champe, Nasby Bldg., Toledo, Engr.

Ohio, Sandusky—The Lake Shore Electric Ry. Co., 129 Columbus Ave., plans to build an electric power substation and install complete machinery, turbines, etc., to replace fire loss. Estimated cost $50,000.

Ohio, Toledo—The city is having plans prepared and will receive bids about Jan. 1 for the construction of a new intake, shore well and addition to present crib (intake) at the Low Service Pumping Plant, Filtration Plant. Estimated cost $60,000. W. G. Clark, 1046 Spitzer Bldg., Engr.

Okla., Ardmore—The Dougherty Sand Gravel Co. is in the market for a 150 hp. motor and a 6 to 8 in. sand pump.

Pa., Altoona—The Penn Cress Ice Cream Co., Front St., Cresson, R. J. Truxler, Pres., A. B. McCullough, Local Mgr., 3225 5th Ave., plans to build a 3 story, 110 x 120 ft. ice cream plant, including office wareroom, refrigeration plant and power house. Estimated cost $150,000.

Pa., Erie—The city, G. C. Gensheimer, Secy. Comrs. of Water Works, 701 French St., will soon receive bids for a 20,000,000 gal. triple expansion high duty pumping engine for filter plant.

Pa., Wilkes-Barre—The Community Hotel, c/o A. J. Sordini, Chamber of Commerce, plans to build a hotel. Cost between $1,000,000 and $1,500,000.

S. C., Greenville—J. A. Wetmore, Acting Supervising Archt., Treasury Dept., Wash., D. C., will receive bids until Dec. 18 for the complete installation of one full magnet electric freight elevator for the United States Post Office and Court House, here.

Tenn., Bristol—The Bristol Ice & Coal Co. plans to build an ice plant. Estimated cost $50,000.

Tex., Dallas—Sutton, Steele & Steele, Inc., Forney Ave., is in the market for a 20 kw. generator, d.c., 220 volt. O. Steele, Engr.

Tex., Galveston — The University of Texas, H. L. Stark, Chn. Bd. Regents, Orange, will receive bids until Jan. 14 for the construction of a 3 story administration building and power house for the Medical College, here. Estimated cost $308,000. H. M. Greene Co., North Texas Bldg., Dallas, Archts. Equipment detail not reported.

Tex., Lubbock—The city voted bonds as follows: streets and storm sewers, $300,000; city hall, $75,000; street lighting, $25,000; light plant $50,000; water mains $15,000. S. Sanders, Engr.

Vt., East Arlington—G. Safford (woodworking) is in the market for a 220 volt, 3 phase, 60 cycle, a.c. 15 hp., 1,200 r.p.m. induction motor complete with rails, compensator and voltage protection.

Wash., Vancouver—The Vancouver Shillapo Dist., J. Wilison, Dir., is having plans prepared for the drainage of Vancouver Lake, including dyking and ditching, also the construction of a pumping plant and sluice gates. Estimated cost $517,488. W. A. Schwartz, Vancouver, Engr.

Wis., De Pere — The city, M. J. Males, Secy., is having plans prepared for reaming and casing three wells, reaming holes to 10 in. diameter, casing with 8 in. w.i. pipe; installing two air lift pumps, one centrifugal pump and engine. Estimated cost $20,000. W. G. Kirchoffer, Dean Bldg., Madison, Engr. Noted Oct. 30.

Wis., Hurley—The city, J. A. Emunson, Clk., received low bid for the construction of a water purification plant and pumping station at Lake Lavina from J. W. Hildred & Co., 721 Commerce Bldg., St. Paul, Minn., $35,200. Noted Oct. 23.

Wis., Madison—A. J. Sweet, 639 West Wilson St. (fruit dealer), is in the market for refrigeration equipment, brine type.

Wis., Milwaukee — The Hotel Wisconsin Realty Co., 182 3rd St., is having plans prepared for the construction of a 5 story service building, including power house, laundry, etc. Cost between $150,000 and $200,000. Holabird & Roche, 104 South Michigan Ave., Chicago, Archts.

Alta., Camrose—The municipality, J. D. Saunders, Secy., plans to install an additional 350 hp. unit and equipment for power plant.

Alta., High River—The municipality, S. W. Salt, Secy., plans to install an additional 75 hp. unit and equipment for fuel power plant.

N. B., Woodstock—The Carleton Electric Co., Ltd., is in the market for material for the construction of a hydro-electric line down the St. John River from a connection with the Maine & New Brunswick Power Co. at Aroostook Falls.

Que., Bagotville—The town is in the market for complete equipment for electric plant.

Alaska, Ketchikan—The Supt. of Lighthouses will receive bids until Jan. 21, 1924 for two internal combustion engine driven air compressors and two oil engines for the operation of diaphone fog-signal at Cape Spencer Light Sta.

CONTRACTS AWARDED

Calif., Hollywood—The Hollywood High School Dist. received low bid for the construction of an auditorium and boiler house from Olcester & Kerr, 1528 Ramona Ave., South Pasadena, $254,500.

Calif., San Diego—The L. R. Lurie Co., 315 Montgomery St., San Francisco, awarded the contract for the construction of a 6 story automobile stage depot and Hotel on North Broadway, here, to Vukicevich & Bagge, 815 Bryant St., San Francisco. Estimated cost $1,000,000. Equipment detail not reported. Pickwick Stages, Inc., 683 Market St., San Francisco, lessee.

Ia., Davenport—The United Ry. & Light Co., 701 Michigan Trust Bldg., Grand Rapids, Mich., will build a 200,000 kw. central station with 55,000 hp. steam turbines on the Mississippi River above here. Estimated cost $10,000,000.

Ky., Louisville—The Citizens Hotel Co. awarded the contract for the construction of an 18 story, 124 x 148 ft. hotel, The Kentucky, on 5th and Walnut Sts. to Rommel Bros., 919 East Broadway, Louisville. Equipment detail not reported. Noted Oct. 13.

N. Y., New York—The Physicians Medical Hotel Corp., c/o Wiseman & Taussig, Engrs. and Archts., 25 West 43rd St., awarded the contract for the construction of a 9 story hospital on 5th Ave. and 103rd St. to the Wells Constr. Co., 237 5th Ave. Estimated cost $800,000. Equipment detail not reported. Noted Dec. 7, 1922.

N. C., Hamlet—The Hamlet Ice Co. awarded the contract for the construction of an ice manufacturing and storage plant, 5,000 lb. daily capacity, to the J. A. Jones Constr. Co., Realty Bldg., Charlotte. Estimated cost $100,000.

Ohio, Van Wert—The Marsh Foundation awarded the contract for the construction of a laundry and power house, piping and heating in connection with orphanage, to Carey & Hall, Defiance, cost plus percentage.

Pa., Bethlehem — The city awarded the contract for the construction of pumping station to the F. H. Clement Co., Inc., Bethlehem, $7,921; pumping equipment and electrical work to the Bethlehem Electric Co., $14,672.55 and $4,353.76 respectively. Noted Oct. 23.

Pa., Phila.—The Phila. & Reading R.R., Reading Term., awarded the contract for the installation of electrical fan and ventilating system in the Mahanoy Tunnel to the Pennsylvania Power & Light Co., Hauto. Estimated cost $100,000.